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Railway Construction in Ecuador Just South of the Equator*

CHARACTER OF THE COUNTRY—Those who habitually think of the regions under the equator in the interior of South America as uninhabitable tropical jungles will read with interest, that one purpose in constructing the Ferrocarril al Curaray, from the junction at Ambato with the existing Guayaquil & Quito R.R.,† to the Rio Curaray, one of the sources of the Amazon River, is to open up an agricultural country called the Oriente, where fruits, vegetables and grains of all kinds are grown the year round. Consequently, the hardships of pioneer railway surveyors and constructors on this work are not so apparent as the title of the article would indicate. In the immediate vicinity of the construction camp at Troja, eight miles east of Ambato, there are grown 84 varieties of fruit, almost every vegetable and all kinds of grain.

Ambato itself is a modern town, situated on about the same meridian as New York City, 1½° south of the equator, but at an elevation of 8500 ft. above sea level. Its climate is delightful, the temperature range is from 42° to 72° F.; the rains are like those of the temperate zones. That it is thoroughly up-to-date is evident, for, besides the municipal offices, barracks and jail, there are a cathedral, two churches, two hospitals, a convent, two government schools and an agricultural college, a large brewery and two clubs. It also has electric street lights and a water-supply. There are about 9000 inhabitants, and on Monday market days 3000 Indians come in from the interior with everything imaginable in the way of things to eat, including celery, peaches, apples, pears, artichokes, alligator pears, strawberries, chiromogas, etc.

FIG. 1. VIEW AT ABOUT KILOMETER 10, FERROCARRIL AL CURARAY, ECUADOR, SHOWING GENERAL CHARACTER OF EASTERN PART OF THE LINE

PRELIMINARY SURVEYS—On Mar. 13, 1905, Gen. Leonidas Plaza, President of the Republic of Ecuador, through his Minister of Commerce and Labor, Luis A. Martinez, contracted with Charles H. Moore, then First Assistant Engineer of the Erie R.R., New York City, to make the necessary surveys and preliminary investigations for a railway from Ambato to the Rio Curaray, a distance of 180 miles. Mr. Moore took with him to Ecuador seven American engineers, with a complete outfit of instruments and camp equipment. Walter G. Fox,

*Photographs and data furnished by Charles H. Moore, Director of Engineering and Construction, Ferrocarril al Curaray, Ecuador; 2 Rector St., New York City.

†The Guayaquil & Quito R.R. was built, 1900-1903, by American engineers, of whom John A. Harman was Chief, and F. W. Bennett, Assistant Chief. A full account of the construction work may be found in "Engineering News," Aug. 11, 1904, pp. 114-119.

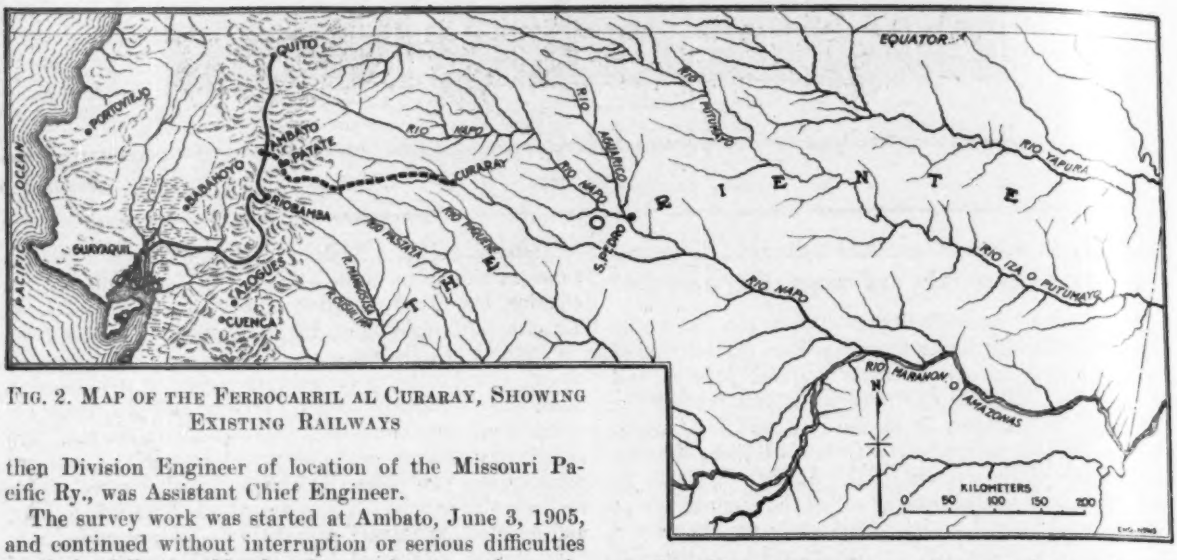

FIG. 2. MAP OF THE FERROCARRIL AL CURARAY, SHOWING EXISTING RAILWAYS

then Division Engineer of location of the Missouri Pacific Ry., was Assistant Chief Engineer.

The survey work was started at Ambato, June 3, 1905, and continued without interruption or serious difficulties until the following March, when, owing to a change in the personnel of the Ecuadorian government, the survey work had to be dropped. In the meantime, however, a reconnaissance of the entire 180 miles had been made, and about 75 miles of preliminary line had been run out. Over this distance, accurate cross-sections had been taken, and contour maps were completed. About 12 miles of the final location had been staked out.

In making the final location, the kind of labor to be employed, the available tools and the want of transportation facilities had to be considered as well as an elaborate irrigation system, which could not be disturbed. As originally projected, 2% was to be the controlling grade, but the construction of the existing north and south railway at a greater elevation than was formerly contemplated necessitated the use of 9 kilometers of 2½% grade (compensated for curvature). This grade was concentrated at the western terminus (Ambato) and the descent to the river bottom was made as rapidly as possible. From this point on the controlling and maximum grade will be 2%.

CONSTRUCTION—In August, 1906, the proposal to construct the railway was revived and it was determined to proceed with the funds then in hand. Tools and equipment for 1000 laborers were purchased and shipped from the United States, but actual construction work was not begun. In August, 1910, bids were asked from contractors for construction, but no bids were accepted, because the condition of the financial world prevented the sale of a proposed bond issue.

When Gen. Plaza was reëlected Constitutional President, in 1911, he revived his former aggressive policy of internal development by the construction of public works, among which was the projected Ferrocarril al Curaray. It was concluded that the national government could do the work directly, avoiding a bond issue, expenses of promotion, contractors' profits, etc. A contract for directing the engineering and construction work was according-

FIG. 3. GRADING BY PASSING EARTH BETWEEN TIERS OF SHOVELERS

FIG. 4. CONSTRUCTION WORK ON THE FERROCARRIL AL CURARAY

[(1) Carrying stone for masonry on burros. (2) Opening a side-hill cut. (3) Inspection by the chief. (4) Line staked out; tops of poles indicate grade. (5) Grading from Borrow Pit on line. (6) Excavation in cut. (7) Embankment at Sta. 43; tool tent on left. (8) Wheelbarrow brigade.]

ly entered into with Charles H. Moore, who was then Principal Assistant Engineer of the Erie R.R., and Walter C. Fox, then Engineer-in-charge of construction of the southern extension of the Mexican National Ry.—the same engineers who had made the preliminary survey.

It was determined by the government officials to make the construction work a training school for native engineers, who had been to college at home and abroad, but who had had no practical railway experience. The bulk of the engineering corps is therefore made up of native Ecuadorians, some of whom were on the preliminary survey. The American engineers are Hugh Latimer, Chief of Party, formerly Assistant Engineer of the New York

Central & Hudson River R.R., A. C. Houston, Engineer of Construction, formerly Resident Construction Engineer of the New York Central & Hudson River R.R., and I. P. Seabright, formerly Assistant Track Engineer of the Pennsylvania R.R., at the Sunnyside yards, Long Island City, N. Y.

The difficulties to be met by the American Directors of Engineering and Construction at the beginning of the work in November, 1912, were an anti-Yankee propaganda in the public press, a congress not altogether in sympathy with the Chief Executive, negotiations with a junta of seven men (of as many different minds), and with ways and means of accomplishing the work undefined, contract restrictions on the employment of foreign engineers and laborers, the collection and utilization of the laborers' tools, shipped eight years before, and the problem of organizing and training inexperienced native Indian workmen. Seven weeks of negotiation settled the difficulties with the government, it being decided to do the work directly through the Minister of Public Works, the funds to be raised by special taxes.

The native Indian laborers not only had to be organized into construction gangs, but educated in the use of pick, mattock and shovel—and the meaning of an organization. The rate of pay at the start was 20c. (gold or equivalent in U. S. currency) per day, which was later increased to 25c. The working hours were from 6 a.m. to 11 a.m. and 1 p.m. to 5 p.m. Native foremen were found, who could efficiently handle gangs of 20 to 25 men. For the first four months the chief difficulty was the holding of laborers; every Monday morning meant a complete reorganization of the force. This difficulty was finally adjusted by the men working in pairs, so when one wants to lay off, as is his frequent inclination, his "brother" takes his place. This means carrying 1500 to 1800 men on the weeklfy payroll for an average working force of about 1000; but the practical results are satisfactory; the native Indian laborers have proved very efficient and individually handle about 35% more material than the same class laborers in the States.

Methods of Construction—The accompanying views give an idea of how the grading is done. The entire work is by hand, where possible, by passing the earth from row to row of shovelers and elsewhere by the use of wheelbarrows. The maximum efficient wheelbarrow haul was found to be 600 ft. The general specifications and classifications are similar to those in the United States, except that the gage is only 42 in. and the width of the road bed is 4 m. (13 ft. 1 in.) on embankment and 4.5 m. (14 ft. 9 in.) in cuts. The rails used are of the Am. Soc. C. E. section, weighing 55 lb. per yd., and are laid on native wood ties averaging about 1700 per kilometer.

The earthwork consists of the excavation of compacted volcanic dust—a very fine, almost impalpable powder when shaken up, but which stands at a safe angle in cuts of ¼ on 1, and necessitates the use of pick and mattock to loosen. There is little solid rock excavation, indeed proper stone for the necessary masonry structures is hard to get and has to be brought on the backs of burros from distances of 5 to 20 kilometers.

There are no roads through this region, and up to the present time the difficult trails were practically never traversed except by prospectors in search of gold, for there is gold here as well as indications of petroleum. The transportation of anything which could not be carried on the backs of men or burros was impossible, and the difficulty and expense of constructing proper roads and their maintenance through such a country is not justified under present conditions.

Even cement for the masonry structures could not be brought in until the grade was partially completed; but this difficulty was easily solved by the use for mortar of a good local lime, until cement arrived. There are to be no openings in the track except at river crossings; the smaller stream crossings are arch culverts of first-class masonry of from 1- to 2-m. span. Bench walls are second-class, foundations second- and third-class and retaining-walls second-, third- and fourth-class masonry but all are laid in mortar.

There is, however, plenty of timber. On account of the forests, which commence a short distance from Baños, the last town eastward, wood will be used for fuel in operating the railway until traffic warrants, when abundant water power will be developed for operation by electric traction.

Characteristics of Railway Line—For the first three miles out of Ambato the line passes through well kept haciendas on the right-hand bank of the Ambato River, descending on the controlling grade. At the village of Quillan, 5 miles from Ambato, the grade changes to between 1% and 2%. About 10 miles from Ambato is the confluence of the Rios Ambato and Culapachan and the entrance to the cañon of the Rio Patate, which is 280 ft. deep and three miles long. Fifteen miles from Ambato is the village of Patate and a mile farther the town of Pelileo, having a population of 3000, and located in the center of an agricultural district producing alfalfa, grain, sugar cane, fruits and vegetables. At Pelileo, the original location was 300 ft. below the town, but investigations are now under way to determine the cost of developing the line into the town.

Baños, a town of 3500 population, is 29 miles from Ambato, and is also the center of a large agricultural district. It is practically the end of civilization to the eastward and beyond it the forests begin. At Baños are boiling springs, from which the town derives its name, and which are much frequented because of the medicinal properties of the waters. The town has the usual stores, a small foundry, hotel, church and a cabinet shop, the proprietor of which holds a certificate of award of the World's Fair, at St. Louis, 1904. From Baños eastward, all kinds of hard and soft woods are found in abundance, and these have been pronounced suitable not only for building purposes, but for cabinet work and all kinds of furniture. Four miles beyond Baños are the Falls of Agoyan, which are capable of developing 260,000 hp. The falls are 198 ft. high and the location for a power plant is ideal.

East of the Falls the grade descends at the rate of 1.2% to 0.5% passing the Rios Margajitas, Negro and Topo, where there are indications of gold, and the Zumag, through a heavily timbered country. Barrancas, 55 miles from Ambato, at the confluence of the Rios Alpa Yau and Pastaza, is situated on a level plain, many miles in extent and at an elevation of 3500 ft. above sea level. Here the government has established a small agricultural experiment station. In the vicinity are found yucca, plantains, sugar cane, beans, potatoes and corn. The climate is agreeable, 62° to 75° F., with a rainfall similar to that of the temperate zone. Beyond is the Puyo Valley and

near-by the Castagnas Mountains, in which are the sources of the Rio Curaray. From this point eastward, the temperatures are higher and the humidity increases, until the village of Curaray is reached, at an elevation of 1270 ft. above sea level, which is in the typical tropics; rubber, cocoa, tobacco, quinine, coffee and vanilla are found growing in a wild state. The village of Curaray is accessible at all times from the Amazon River for cargo boats of 3-ft. draft.

Cost Data—Average unit cost data for the part of the work already completed are given below. These costs include labor, superintendence, materials and all expenses except overhead charges of office and engineering. In reducing the unit costs to U. S. currency, the value of a sucre is taken at $0.487.

COST DATA*

	Per sq.m.	Per sq.yd.
Clearing and grubbing	$0.041	$0.035
	Per cu.m.	Per cu.yd.
Grading, earth	$0.0535	$0.041
Grading, hardpan	0.128	0.098
Grading, loose rock	0.270	0.206
Grading, solid rock	0.638	0.486
Dry foundations	0.144	0.110
Ditching	0.072	0.055
Foundations (loose rock)	0.312	0.238
Grading highways	0.071	0.054
Dry foundations for walls	0.102	0.078
Grading private road	0.085	0.065
Excavation from borrow pits	0.065	0.050
First-class masonry	9.91	7.56
Second-class masonry	7.05	5.39
Third-class masonry	4.10	3.13
Fourth-class masonry	1.33	1.01
Wet foundations	0.76	0.58
Ditching, loose rock	0.27	0.21

Cost data for first 10 kilometers only.

The quantities involved in computing some of these unit costs are so small as to be misleading, but the whole gives a very fair comparison with similar work in the States. The work requiring skilled labor, such as masonry, shows a steadily declining scale of unit costs, those for the ninth and tenth kilometers being about one-half of those for the first and second kilometers, due to the increasing experience of the laborers. The average cost per kilometer of the completed grade for the first seven kilometers completed is $2930, or $4730 per mile.

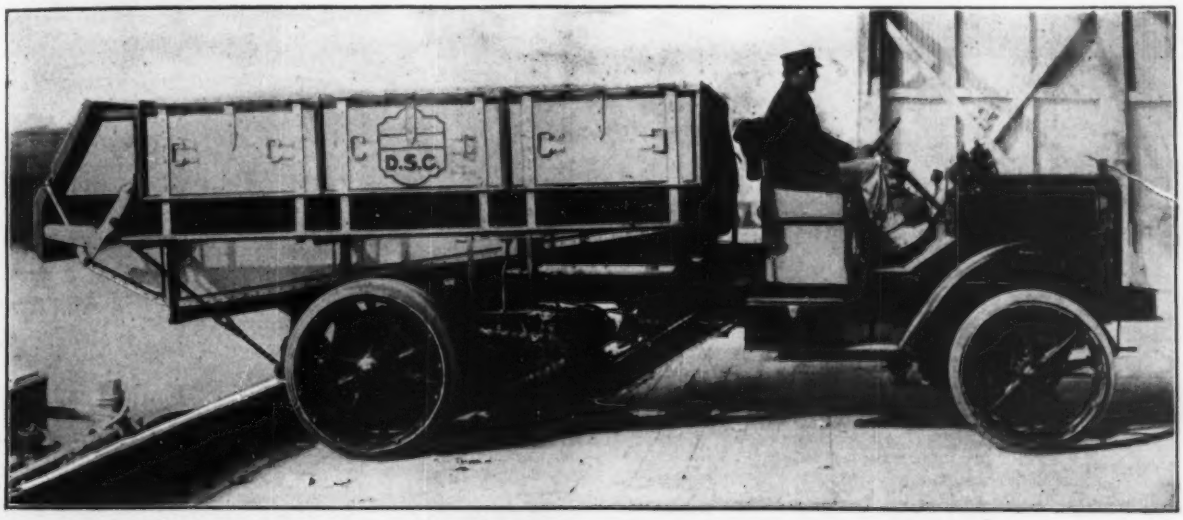

Fig. 1. New Auto Truck of New York Department of Street Cleaning

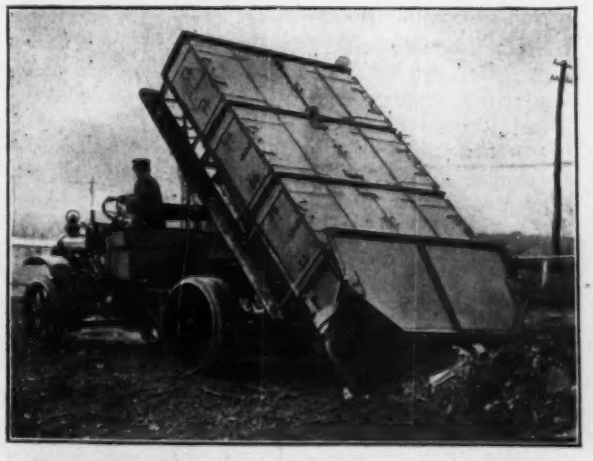

Fig. 2. New York Street-Cleaning Truck Dumping on Land Fill

Motor Trucks for Refuse Collection in New York City

The special motor truck shown in the accompanying figures has been designed and built by coöperation between the engineers of the Street Cleaning Department, City of New York, and the White Co., in an endeavor to lessen the labor and lost time of collecting ashes and garbage.

This type has a peculiar frame, ordinary in front and underslung rear, to keep the body at low elevation. The drive and dump mechanism is placed forward of the rear axles and about in this horizontal plane. The sides and top covers are made in sections and the crew does not have to lift the refuse cans more than waist high. The body is 7 ft. 6 in. by 13 ft. 3 in. and has a free space of 252 cu.ft.; the capacity is for about 120 cans of ashes equivalent to five one-horse loads. In dumping the body is elevated to an angle of 53°.

The trial unit is working in a district where the haul to the dump is three miles. This distance is covered in 14 minutes. One man drives the truck and operates the power dumping mechanism.

Driving the Water Intake Tunnel at St. Louis

By E. C. Davis*

The new intake at the Chain of Rocks (Mississippi River) for the water-supply of the city of St. Louis was described in Engineering News, Feb. 12, 1914, together with some of the troubles experienced with the present intake. The work comprises an 8-ft. rock tunnel about 2800 ft. long from a screen chamber at the present pumping station to an intake shaft and tower in the river.

The surveys were made and the location of the intake tower determined during the summer of 1912. Plans and specifications were completed in March, 1913, and the contract was let to the Fruin-Colnon Contracting Co., in June, 1913. The price for tunnel excavation was $16 per cu.yd. The intake tunnel connecting the intake tower with the screen chamber has been completed. This tunnel, circular in section, was driven with a diameter of 10 ft., and when lined with concrete, will have a diameter of 8 ft.

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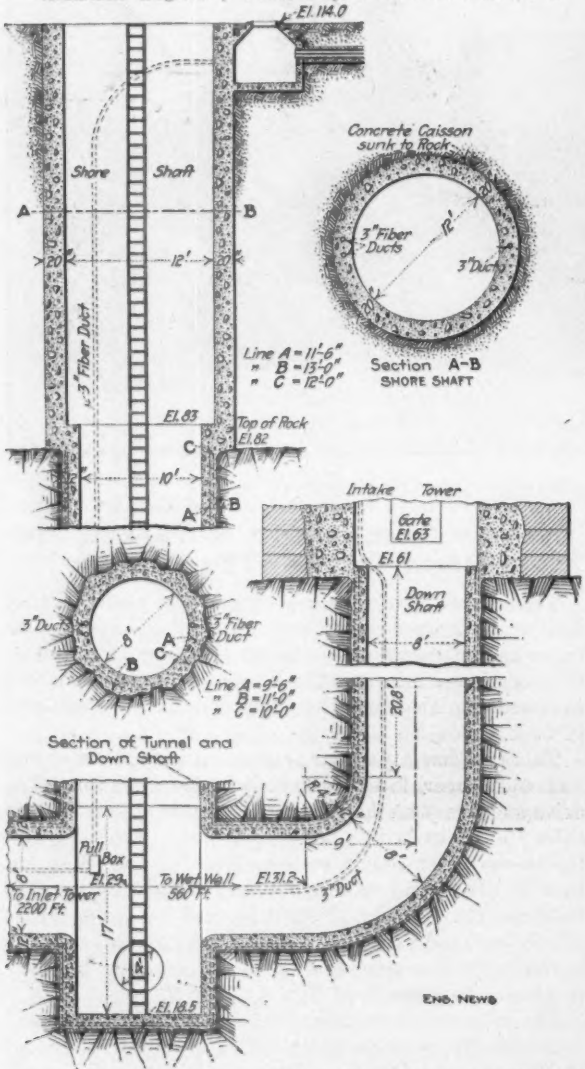

Fig. 1. Intake Tunnel and Shafts for New Water Intake at St. Louis, Mo.

In the section, Fig. 1, the lines *A*, *B* and *C* are reference lines governing the estimated quantities and the thickness of the concrete lining. Line *A* is the line within which no unexcavated material of any kind, no timbering, bracing, metallic or other support will be permitted to remain. It represents, therefore, the minimum thickness of lining. Line *B* delimits the excavation to be paid for, whatever the areas of the section actually excavated. In certain specified cases this is also a payment line for masonry and dry packing. It is fixed arbitrarily 9 in. outside of line *A*, except adjacent to permanent supports, where it is as nearly as practicable 9 in. outside the support, not counting bolt heads.

Line *C* is the line of effective average thickness of masonry lining. Rock or other foreign material was permitted to remain within this line only under circumstances such that the effective strength of lining against external pressure, considered in lengths not exceeding 4 ft., was not thereby reduced. This line in unsupported portions of shafts and tunnels in rock was 3 in. outside of line *A*. Any edges of flat surfaces of rock remaining within it to an extent or in a manner which would impair the strength of the lining had to be trimmed away sufficiently to make an effective average thickness at least as great as to line *C*.

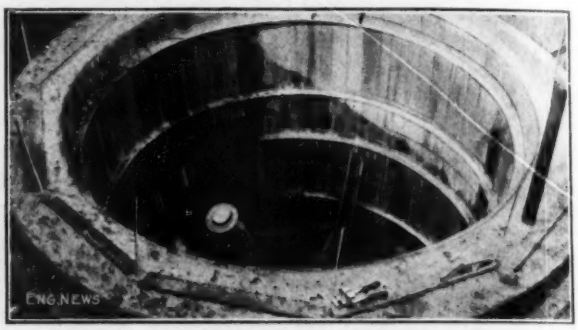

Fig. 2. Concrete Crib for Shore Shaft Sunk through Earth and Quicksand

In the screen-chamber excavation, trouble was anticipated due to caving. To guard against this, steel sheet piling was driven 4 ft. outside the dimension lines, which in earth were 34x30 ft. 10 in. The piling was braced horizontally with sets of 10x12-in. timbers, placed approximately 7 ft. c. to c., and set as the excavation advanced. This excavation was carried 20 ft. in earth and 9 ft. in quicksand without any serious difficulty. Rock was first excavated with a length and width of 18½x17 ft., and to a depth of 29 ft. Then the shore tunnel was driven from the bottom of this shaft and rock was excavated from the top and bottom (for screen chamber and tunnel) at the same time, which resulted in a saving of time and expense.

The shore shaft, located on the bank of the river, approximately 100 ft. from the water's edge [and 600 ft. from the screen-chamber shaft] was used as a working shaft in driving the tunnels. This shaft is shown in Fig. 1. The upper part, in earth and quicksand, was excavated with a diameter of 15 ft. 4 in. to a depth of 21 ft. in earth and 12 ft. in quicksand by means of an open concrete crib. This crib, Fig. 2, was built in place as the excavation advanced. No water appeared

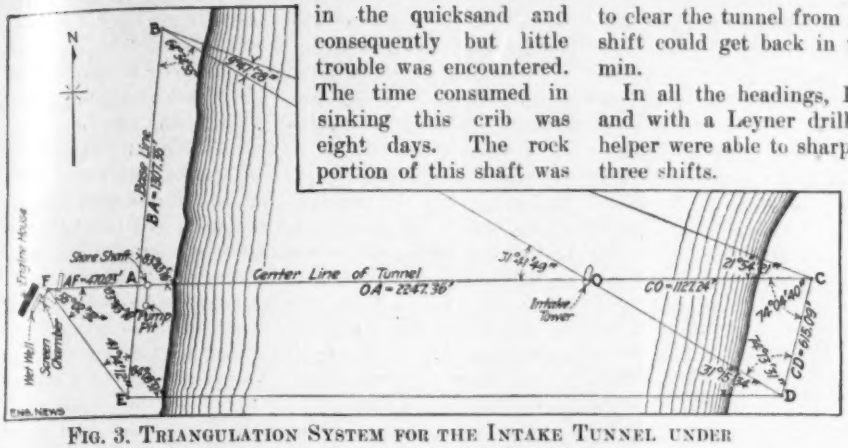

FIG. 3. TRIANGULATION SYSTEM FOR THE INTAKE TUNNEL UNDER THE MISSISSIPPI RIVER AT ST. LOUIS, MO.

in the quicksand and consequently but little trouble was encountered. The time consumed in sinking this crib was eight days. The rock portion of this shaft was excavated with a diameter of 12 ft. and did not vary from the usual methods employed in sinking shafts.

The progress was greatly retarded by running into a number of water seams near the surface of the rock, which gave a flow of approximately 100 gal. per min. An attempt was made to grout these seams and to a certain extent was successful, although more or less water appeared at different elevations and a 3-in. discharge pump was required to take care of this water. The presence of this pump and time consumed in taking it out and setting it up again at the time of shooting proved to be quite an obstacle in the way of progress, as 34 days were required to sink the shaft 63½ ft., working two 8-hr. shifts a day.

From the working shaft or shore shaft, the shore tunnel was driven west a distance of 556 ft. with a 6% grade ascending to the screen chamber, and the river tunnel was driven east a distance of 2198 ft. with a rise of 1 in 1000 to the intake tower. A south tunnel, through which the main tunnel is drained, was driven a distance of 103 ft., with a grade of 0.25% to the present pump pit shaft.

In July, 1913, the final location of the tunnel was made by a party of four men under the direction of the writer. A base line 1877.69 ft. in length was laid out along the west shore of the river, and a triangulation system laid out as shown in Fig. 3. From this the length and direction of the tunnels were determined.

Construction Plant

The power and compressor plant was located just north of the shore shaft, and consisted of three 75-hp. boilers and a two-stage air-compressor with a capacity of 950 cu.ft. per min., maintaining a pressure of 110 lb. in a receiver 3x10 ft. placed outside the compressor house. The air line was 4-in. diameter from the receiver to the bottom of the shaft, and 3-in. to the face of the heading, reduced at the end by a 2-in. manifold to receive the air hose for the drills.

A rotary pressure blower with a capacity of 4.8 cu.ft. per rev., running at 325 r.p.m., was used for ventilating the tunnel. This was belted to a 25-hp. direct-current, 500-volt motor, running at 800 r.p.m. An 8-in. ventilating pipe was laid from the blower house through the tunnel to within 100 ft. of the face of the heading, and was extended as the work progressed. The average time to clear the tunnel from smoke and gas in order that the shift could get back in the heading was from 12 to 20 min.

In all the headings, Ingersoll-Rand drills were used, and with a Leyner drill sharpener one blacksmith and helper were able to sharpen in 8 hr. all steel used on the three shifts.

For transporting muck to the shaft, a track of 24-in. gage was laid on the south side of the tunnel and wooden cars of 24 cu.ft. capacity were used, as shown in Fig. 4. These were hauled by a 25-hp. storage-battery locomotive weighing 3 tons and having a hauling capacity on level track of 10 tons. The muck was hoisted up the shaft by means of two cages, each large enough for a car, operated by a two-cylinder link-motion reversible hoist, equipped with a drum 48 in. diameter and 48-in. face.

More or less water was anticipated in the east heading, as this end of the tunnel is located under the bed of the river, and facilities for handling 900 gal. per min. were provided. However, the maximum flow of approximately 350 gal. per min. was obtained at the time the tunnel was completed. This water gave little or no trouble, but on account of the slight grade in the east heading a pump of 100 gal. capacity was necessary to keep the water from the face of the heading.

The electricity for lighting purposes in both tunnel and camp, and for running all motors, was obtained from the 2300-volt, 60-cycle, single-phase alternating current from the water-works generator house, at the cost of 3½c. per kw.-hr. to the contractor, who furnished the meters and transformers.

Tunnel Work

The tunnel force consisted of three shifts working eight hours each, each shift composed essentially as shown in Table I. In addition, on the day shift there were a blacksmith and helper at $1 per hr.; 1 foreman, at 60c. per hr.; four laborers at 35c. per hr., working on track; and one mechanic $100 per month, repairing drills and other machinery.

TABLE I. FORCE FOR EACH SHIFT ON THE ST. LOUIS WATER INTAKE TUNNEL AT ST. LOUIS

1 Superintendent, per month	$260	1 Motorman, per hr.	50c.
1 Heading boss, per hr.	62½c.	1 Switchman, per hr.	35c.
4 Drill runners, per hr.	45c.	2 Cagemen, per hr.	35c.
4 Helpers, per hr.	37½c.	1 Electrician, per hr.	50c.
1 Muck foreman, per hr.	60c.	2 Engine men, per hr.	87½c.
8 Muckers, per hr.	35c.	1 Fireman, per hr.	40c.
1 Nipper, per hr.	37½c.	1 Pump man, per hr.	50c.
1 Signal man, per hr.	35c.	3 Laborers, per hr.	35c.

At the beginning of the work one round was drilled and shot per shift. The drills were then mounted on two columns, one on each side of the heading, with two drills mounted on each column, the 10-ft. cut holes and 8-ft. side holes were drilled, and this round pulled from 4 to 5 ft. per shot. After the organization was more complete, four shots per day were obtained. Columns were still used during this period, and a round of 10-ft. cut holes and 8-ft. side holes were drilled; this broke an average of 5.16 ft. per shot.

During this latter period the 8 a.m.: 4 p.m. shift found the heading as left just after the last shot on the pre-

vious day. They mucked out, set up the drills, drilled the round, and shot it between 2 and 2:30 p.m. The shift went in immediately, mucked out the heading again and had the drills set ready for the 4:12 p.m. shift. This latter shift drilled the round and shot it between 7 and 8 p.m.; immediately mucked back, set up the drills and drilled another round. Then the 12:8 a.m. shift shot this round between 1 and 2 a.m.; drilled another and shot it between 7 and 8 a.m. The average daily progress in this schedule was 20.6 ft. The time of the various operations was as shown in the first column of Table II.

TABLE II. TIME OF OPERATION FOR DRILLING TUNNEL

	First method	Final method
Clearing gas	18 min.	13 min.
Mucking back	62 min.	27 min.
Setting up drills	28 min.	25 min.
Drilling	2 hr. 55 min.	1 hr. 55 min.
Blowing out holes	12 min.	8 min.
Loading	19 min.	17 min.
Shooting	44 min.	30 min.
Total	5 hr. 58 min.	3 hr. 55 min.

The efficiency of the organization was further increased, and during the last two months two rounds were drilled and shot per shift, or six shots in 24 hr. With this schedule, the drills were set on arms mounted on a horizontal bar approximately 6 in. above the center of the tunnel, as shown in Fig. 5. This was held in position by a jack screw, tightened against the sides and supported in the middle with a jack screw against the bottom. Four drills were thus mounted, two above and two below spring line. The entire round of 16 holes was drilled from this one position of the bar, with cut holes 6 to 8 ft. and side-round holes 4 to 6 ft. deep, depending upon the time allowed to get the second shot.

FIG. 4. DUMP CAR OF 24 CU.FT. CAPACITY AND 24-IN. GAGE, FOR THE INTAKE TUNNEL AT ST. LOUIS, MO.

FIG. 5. TUNNEL-DRILLING CREW WITH FOUR DRILLS MOUNTED ON A HORIZONTAL BAR ACROSS THE HEADING

Fig. 6 shows the general method of drilling, and each shot resulted in an average advance of 4.27 ft. or 25.6 ft. per day. The time of the various operations was as shown in the second column of Table II. Each man drilled four holes. The cut holes (1, 2, 3, 4, 5, 6) were shot first; next the side-round holes (7, 8, 9, 10, 14, 15, 16) were shot. Then the breakdown holes (11, 12, 13, 17) were shot last. Hole No. 7 was used only when the bottom was high and this hole was shot with the side round. The holes were started with a diameter of 2½ in. and bottom with a diameter of 1½ in. All shooting was done by means of electric current.

Three strengths of blasting gelatin were used at various times: 40% was found to give too much smoke and gas, 60% was too strong, the explosion was too quick and consequently would break near the surface of the holes and not at the bottom. Finally, 50% was used, and with this the best results were obtained. The charge varied both as to the depth of the hole and the quality of the rock, but on an average one stick (1½ x 8 in.) per lin.ft. of hole was used. An average of 6.7 lb. of powder was used per cu.yd. of excavation.

The muck was loaded into the cars by 8 men using pointed shovels. Steel plates ¼ in. thick were laid on the bottom, extending back about 25 ft. from the face; the muck from the shot fell on these plates and shoveling was made comparatively easy. A trip of empty cars was pushed up near the heading, and all but one were tipped off the track. This car was first loaded and pushed back beyond the empty cars; then one of the empties was put on the track and loaded in the same way, and so on until all the cars were loaded. Then they were pushed up near the muck pile and a new trip of empties was brought up and tipped off the track, and the loaded cars were run to the shaft. At the surface they were run on a 24-in. gage track to the dump.

The rock encountered was St. Louis blue and gray limestone, easily drilled and shot. A few horizontal seams and occasionally soft places were run into. These gave but little trouble, and timbering was unnecessary. Both headings were turned Sept. 26, 1913. The west heading was holed Dec. 17, 1913, and the east heading holed Mar. 4, 1914. No effort was made for a record on this work, but for the week ending Feb. 19, 1914, 184 ft. of tunnel was driven, and from Jan. 21 to Feb. 21 (inclusive) 745 lin.ft. were driven in the east heading. The writer believes that this latter set a new record in the United States for tunnel driving. The heading was driven to a finished line and grade, and the actual excavation ran approximately 10% under that which was paid for under the specifications.

A bonus system of payment was used. A minimum progress of 72 lin.ft. per week was established, and over this the rates in Table III were paid per lineal foot of tunnel driven, the payment being divided equally between the three shifts. This amounted to approximately $4.60 per lin.ft. No man who had lost over three shifts during the week was allowed a bonus. About 905 lin.ft. of

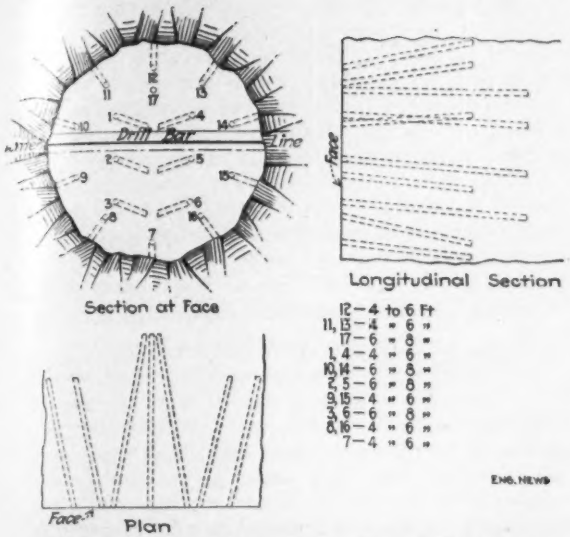

FIG. 6. ARRANGEMENT OF DRILL HOLES

tunnel came under this system and was paid for by this bonus.

TABLE III. BONUS PAYMENTS ON TUNNEL WORK

Superintendent	50c.	Muckers	10c.
Heading boss	50c.	Nippers	20c.
Drill runners	30c.	Cagemen	10c.
Drill helpers	20c.	Switchmen	10c.
Muck foreman	30c.		

E. E. Wall is Water Commissioner; Gurdon G. Black is engineer-in-charge of the Supply and Purifying Division; C. H. Hollingsworth is General Superintendent of Construction, and the writer is Assistant Engineer-in-Charge of the construction.

Another Answer to "What Is the Matter with Irrigation?"

BY W. W. PATCH*

Throughout the western portions of the United States and Canada, public opinion is much aroused over the general lack of satisfactory development which characterizes the majority of irrigation enterprises, both corporate and national. Many reasons have been assigned as being responsible for existing conditions, one of the best arguments having been presented by E. P. Osgood, in ENGINEERING NEWS, of Feb. 19, 1914, who shows that lack of adequate capital very often retards progress and embarasses the settler. There are, however, other adverse factors which have to be reckoned with. Some of them are common to all irrigation enterprises, while others are peculiar to the Federal projects. The present writer has lived for nine years in irrigated districts, and from a personal acquaintance with hundreds of irrigators in several different states has concluded that most of their troubles arise from some one or more of the causes outlined in the following notes.

LACK OF THE NECESSARY CAPITAL

The writer does not agree in detail with all the computations made by Mr. Osgood in the article before noted, although in reporting upon the financial equipment required by settlers on a project very closely analagous to the one in Nevada it was found that in addition to the returns from an average farm during the first three years the settler would need cash and equipment valued at $8000 for an 80-acre farm. This study was based upon a water charge of about $4 per annum, and the purchase of private land at $40 per acre with the customary terms of one-quarter down and the balance in three equal annual payments, with interest at 8% upon unpaid installments. The water charges are certainly not above the average, and if we omit any payments or interest upon the purchase of land we have left a capital investment of nearly $4500. Under the assumptions made in this case the settler would start the fourth year free from debt, but in order to do this he is assumed to have had sufficient experience and energy to have sold only the minimum of crops, and to have converted the bulk of them into dairy and pork products. However, at the end of the fourth year and thereafter, given no unusual misfortunes, the typical settler being discussed should be able to figure safely upon a handsome return upon his total investment, including purchase of land at the assumed price. It is probable that more "near failures" result from insufficient capital than from any other single factor.

LACK OF EXPERIENCE

In the past, probably over 90% of the settlers entering a newly irrigated district have had absolutely no experience in farming irrigated land, and at least half of them have been devoid of any experience in farming or horticulture of any description.

Real success can come only as a result of intelligent study of the market conditions, the climate, soil, subsoil, methods of applying water, preparation of land by leveling, proper combinations of crops or rotations of crops, and methods of animal husbandry or horticulture as the case may be. The average newcomer, with his limited capital, must get some return from his land at the earliest possible moment. Hence, often with only the crudest kind of leveling or none at all, grain is planted, and the result frequently is that the average yield per acre is but five bushels more than would have been obtained by dry-farming the same land, while if the grain is wheat the mill will pay from five to ten cents per bushel less for it than if it were raised on dry land. The writer has seen this operation repeated by the same parties for as many as five years in succession.

The agricultural schools of California and Oregon for a number of years past have been carrying the campaign of education to the farmer by means of demonstration trains, farmer's short courses in the winter months, traveling lecturers, etc., and in time great good will result from these methods. This last winter the University of California, assisted by the Southern Pacific Railway, put into effect the novel plan of giving a short free course in agricultural instruction at the State school, at Davis, to all the clergymen of the State of California who cared to attend. These attended to the number of many hundreds, without any expense to themselves for transportation or other items, and after assimilating all the agricultural knowledge they could absorb returned to their flocks to preach salvation through modern-agricultural methods.

Every irrigation project is probably best adapted, on account of its markets or for other reasons, to development along some particular lines of agricultural effort,

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and the preparation of the land and the methods of irrigating from the first season should be such as to best serve this end. The unfortunate experiences of many of the earlier irrigators, due to misdirected efforts, have had an important educational effect; while the great activity of the leading Western agricultural schools is having a marked influence in preventing such wholesale mistakes as have been made in the past.

Lack of Physical Qualifications

Operating an eighty-acre irrigated farm is no job for the aged, crippled, or persons lacking a rugged physique. The writer has known of but relatively few failures on account of defective physical equipment, if we except the chronically lazy who are always in evidence. He has, however, answered many letters from persons intending to buy irrigated farm land which by their tone indicated that the writers were looking for light work to occupy their declining years. Such settlers should be discouraged from undertaking certain failure. Irrigated land produces so much heavier and more frequent crops than dry-farmed land that farming an equal area entails much more work than the ordinary farmer is accustomed to.

Speculative Farming

Among the causes for the failure of farmers on irrigated lands, speculative farming is a close second to insufficient capital. By speculative farming is meant the pernicious practice of a settler investing almost all of his available capital in the first payment on a large body of land, leaving practically nothing for development, and planning to sell all or part of his interest at an advance before the next payment is due.

Damage from the Elements

Damage from the elements is about the least adverse factor that the farmer of irrigated land has to face. Occasionally an unseasonable storm will damage his hay or fruit, and in some localities he has to reckon on an occasional loss from frost. In regions subject to violent hail storms a total loss of crops sometimes happens; but in the vast majority of cases a hail storm travels in a very narrow path, hence any individual has the chance greatly in his favor that he will escape damage. All things considered, the farmer on irrigated land has less to contend with from the elements than has his brother on dry farms or in the humid region.

The Politics of Irrigation Farming

Federal reclamation projects are subject to one trouble which is peculiarly their own. This is due to a group of pettifogging lawyers and peanut politicians who on some projects are seeking to figure in national politics as the champions of the downtrodden and oppressed farmers. In one town of about 4000 population, on a Federal reclamation project, there were over forty lawyers; probably ten times what legitimate business required. If some of these men could not start some kind of trouble they would starve to death, hence as might have been expected trouble soon became endemic in that part of the country.

On the project referred to, operations had been under way for about two years, with an average crop return of about $15 per acre. This was less than half the return upon the well managed farms, but was nevertheless sufficient to pay expenses upon the average farm, provided the area being farmed was not beyond the capacity of each individual farmer to care for. Then the idle attorneys and a few unsuccessful farmers organized an efficient political machine, which, while representing only 10% of the farmers, yet was able to control the election of officers in the farmer's organization, and dictate the policy of political agitation which then ensued and has continued to date. Charges were brought against various officials connected with the work, several investigations were demanded and were had, and in every possible way the legitimate progress and development of the project were hampered, with absolutely no beneficial results except to a few individuals who had trips to Washington, pocketed attorney's fees or made political capital by the agitation.

Lack of the Coöperative Spirit

The proper and economical operation of an irrigation project demands a highly developed spirit of coöperation from the residents thereof. Almost every step in the process of irrigating the land and disposing of surplus water requires from each settler a consideration of the rights and interests of his neighbors, who should not be deprived of water when needed nor be swamped with overflows from the parties owning land above them. Noxious weed seeds are quickly distributed over large areas by irrigation water, so that in maintaining clean ditch banks, as well as in various other ways, the interests of a community of irrigation farmers are very closely bound together. As a matter of fact, however, upon many projects the coöperative spirit is conspicuously lacking, and in a large measure this fact explains the unsatisfactory development of such communities. If neighbors are continually wrangling over each others use or abuse of water they are not likely to coöperate in the buying of seed or machinery or in the selling of products.

What Is the Remedy?

The remedy for the present unsatisfactory conditions lies in the more careful selection of the class of settlers and in the growth of the coöperative spirit. Lands for sale should be listed with some strong central organization for definite periods of time, so that it could ship in settlers and know that the price of land would not be raised simultaneously with the settlers' arrival, as has happened so often in the past. This same organization should see that intending settlers had the necessary capital and experience, or should be in a position to find additional capital for them if they were found competent in other ways. Loans of this character should bear not to exceed 6% interest. Settlers should be discouraged in every way from taking more land than they can farm to advantage in the first five years of occupancy; and finally coöperation should be preached and practiced upon every possible occasion and to the fullest extent.

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Tests on the Behavior of Concrete in Sea Water conducted under the supervision of the Aberthaw Construction Co., of Boston, Mass., are described in a recent booklet issued by that company. In 1909 a number of reinforced-concrete posts were made from different materials, with different proportions and degrees of wetness and were hung from a pier in Boston harbor subject to tide variation and the ice conditions there prevalent in winter. From time to time these posts have been examined and their condition has been reported in the columns of "Engineering News." The recent booklet describes the test in detail and gives a description, with views, of the posts when they were examined in December, 1913. In general the only thing that can be stated thus far is that a dense concrete will better resist the combined physical and chemical action of sea water, flotsam and ice than will a porous concrete.

The Mt. Elliott Ave. Trunk Sewer; Detroit, Mich.

The Mt. Elliott Ave. sewer, at Detroit, Mich., now under construction, is a trunk sewer extending from the Detroit River northeast to the city limits, a total distance of 19,570 ft. Section No. 1, forming the outlet, is 3364 ft. long, running under Mt. Elliott, Jefferson and Meldrum Aves. to a point north of Champlain St. It has two types of construction: 2663 ft. of 9-ft. circular section, and 671 ft. of four barrels 5 ft. in diameter. A 30-ft. bellmouth connects the single and four-barrel sections, as shown in Fig. 1.

Sewer Outlet

The principal reason for adopting the four-barrel section was the necessity of reducing the vertical height and keeping the sewer below the street grade in the low ground near the river. For 338 ft. from the bellmouth, the four barrels are of two rings of brick, and are built in open excavation in the clay. For the next 333 ft., from the shore to the outlet at the harbor line, the four barrels are inclosed in a monolithic concrete block 24 ft. 8 in. wide and 6 ft. 8 in. deep, each barrel being lined with a

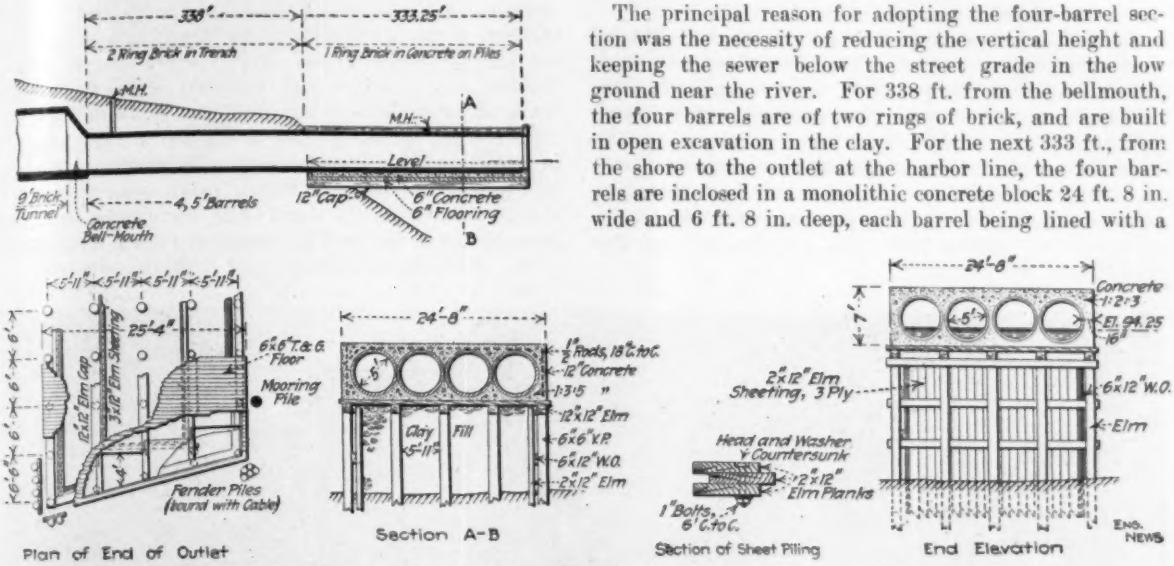


FIG. 1. OUTLET END OF THE MT. ELLIOTT AVE. TRUNK SEWER, DETROIT, MICH.
(Robert H. McCormick, City Engineer. John T. Walbridge Engineering Co., Chicago, Contractor)

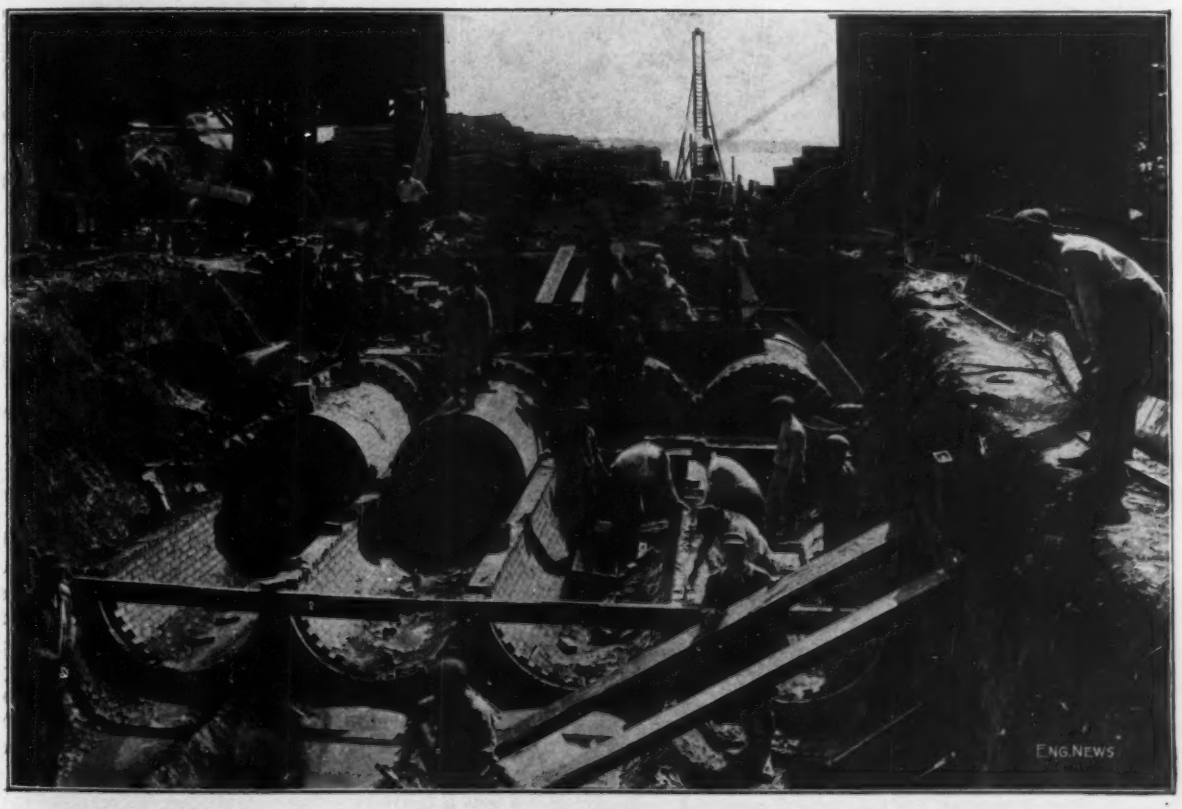


FIG. 2. CONSTRUCTION OF THE OUTLET OF THE MT. ELLIOTT AVE. TRUNK SEWER, DETROIT, MICH.
(Four 5-ft. barrels built in timber cribs on piles and then incased in concrete.)

single ring of brick. This part of the outlet is level.

The concrete work was built in open cribs on a timber deck supported by piling, each bent having five piles 5 ft. 11 in. c. to c. The bents are spaced 8 ft. apart, and carry five lines of 12x12-in. elm stringers, secured by 1-in. drift bolts, no transverse caps being used, except on the end bent. The construction of the outlet section of the sewer is shown in Figs. 1 and 2.

Inside of each outer row of piles is driven a line of Wakefield triple-lap sheet piling, 6x12 in., with three waling timbers. The two lower wales bear against the pile bent, while the upper one bears against the outer stringer. At the middle wales are 1-in. round tie-rods, with the nuts screwed up against 1-in. bearing plates, 12x12-in., on the timbers. The end bent has a 12x12-in. cap to carry the ends of the stringers, and 12x12-in. fillers are fitted between their ends (on the cap) to close the bulkhead or end wall.

but the sides were removed. This type of outlet has been used for a number of sewers at Detroit, but the method of construction described above was devised specially for the Mt. Elliott Ave. sewer.

Sewer Tunnel

The greater part of the 9-ft. circular section of the sewer was built in tunnel. It has a grade of 0.1%. The material is mainly a stiff yellow clay, which is chopped out with picks and adzes. Fig. 3 shows a curve in the finished part of the tunnel, with one of the muck cars. Work was started June 16, 1913, at a shaft on Meldrum Ave. (50 ft. from Jefferson Ave.) and a drift was run in each direction from this shaft. The work is carried on in two 8-hr. shifts; the mining being done in the day shift, while during the night shift, the masons build the brick lining in the portion excavated during the day.

The shaft elevator is equipped with an automatic 18-

Fig. 3. Interior of 9-Ft. Brick-Lined Tunnel; Mt. Elliott Ave. Sewer, Detroit, Mich.
(This shows a curve of 40 ft. radius.)

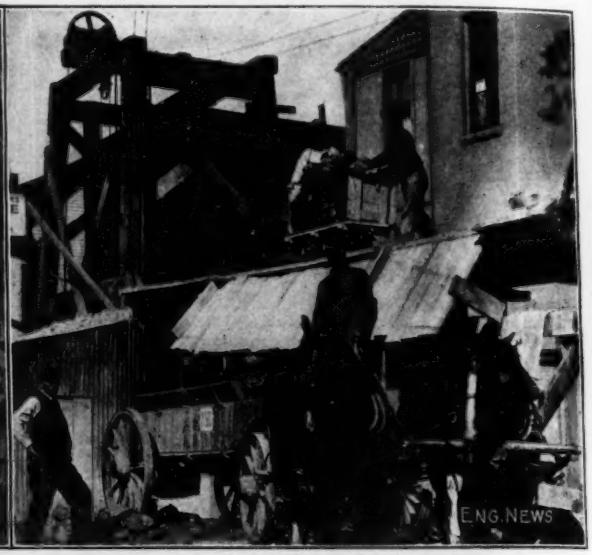


Fig. 4. Headframe of Shaft for Sewer Tunnel
(The elevator is operated by an electric motor, which is stopped automatically, requiring no special attendant.)

The space between the lines of sheet piling is filled with clay to the level of the floor or deck, this giving stability to the structure and enabling it to resist the pressure of the current and of floating ice which is likely to come against it. The piles were driven with a floating piledriver, and a swing saw was used to cut them off at the grade level, about 3 ft. 6 in. below the water. The piles are 20 to 30 ft. long, with bents 8 ft. apart, except that at the end they are 35 ft. long and the bents are 6 ft. apart.

For each 20-ft. length of the work a water-tight box or crib was built, 24 ft. wide inside and 20 ft. long, the floor being of transverse 6x6-in. tongued-and-grooved timbers 26 ft. long. This was floated into position over the piling, and sunk by sand bags and water. The water was then pumped out, and the concrete work built in the dry. When this was completed, the end of the box was removed by withdrawing the bolts, and another 20-ft. box was floated in place against it, then sunk and pumped out, as before. The floor of the box remained in place as the permanent deck (drift-bolted to the stringers),

hp. electric hoist, which stops when the cage is at the proper position at top or bottom of the shaft, so that the attendant has only to throw the lever to start the motor. Small cars of about ½-yd. capacity, on tracks of 13-in. gage, are used to handle all material. The muck cars are hoisted to a platform above the street level, and the material is dumped into wagons. Brick and sand are loaded onto cars on a track at the street level, the cars being then run onto the elevator and lowered into the tunnel. The headframe of the shaft is shown in Fig. 4. Attention may be called to the simplicity of the equipment and to the absence of smoke usually apparent at a tunnel shaft.

The shaft is equipped also with a centrifugal drainage pump, driven by a direct-connected vertical-shaft motor of 7½ hp. The pump impeller is so designed as not to overload the motor under low heads. The motor is waterproof and is protected by an iron shield. The pump and motor are incased in a frame and form a complete unit which is lowered into the sump. The hoist and pump motors are operated by three-phase 60-cycle 220-volt cur-

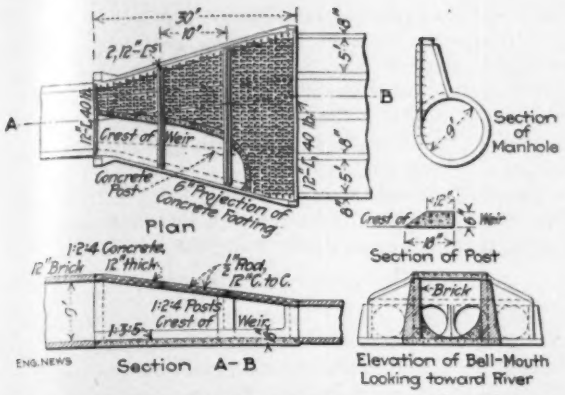


FIG. 5. BELLMOUTH CONNECTING THE 9-FT. TUNNEL WITH THE FOUR 5-FT. OUTLETS

This derrick is of steel construction and carries a 40-ft. boom, while the A-frame is low enough to pass under electric wires or trolley wires without interference. This frame is made in sections, bolted together, and its construction reduces the time and cost of dismantling and reassembling the machine in transferring it from one job to another. It is equipped with a three-drum hoisting engine and separate two-cylinder swinging engine, the hoist being operated by a reversible engine with cylinders 8¼x10 in. The machine runs on 21-in. double-flanged wheels on rails of 12-ft. gage and is self-propelling, the propelling gear being operated through a jaw clutch which takes the place of one of the nigger heads on the hoist.

The machine can be used as a crane or to operate either a clam-shell or drag-line bucket, while a dipper handle (with crowding engine) can be fitted to the boom

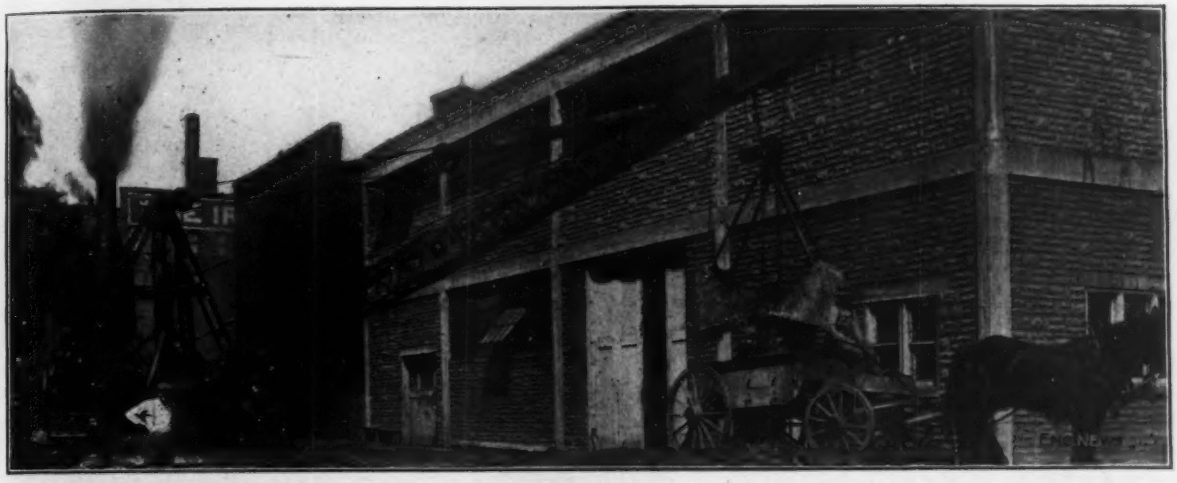


FIG. 6. TRAVELING EXCAVATOR WITH GRAB BUCKET EXCAVATING 26-FT. TRENCH FOR SEWER OUTLET
(C. O. Bartlett & Snow Co., Cleveland, Ohio, builders.)

rent, secured from the local electric lighting company.

BELLMOUTH

The bellmouth connecting the 9-ft. tunnel with the four 5-ft. barrels, is shown in Fig. 5. It has 12-in. vertical brick walls, a concrete floor (1:3:6) on which the invert is formed, and a reinforced-concrete roof (1:2:4). The roof is carried by the side walls and by lines of 12-in. transverse channels. The two outer lines of channels, where the span is long, have intermediate supports consisting of concrete posts standing on the low concrete weirs which divide the invert into three longitudinal portions. At each end of the brick walls is a 16-in. buttress. The bellmouth is 9 ft. wide and high at the connection with the 9-ft. circular sewer, and 26 ft. wide and 5 ft. high at the connection with the four-barrel, 5-ft. sewer.

EXCAVATOR

About 600 ft. of the 9-ft. section and the entire length of the four-barrel section on shore, as well as the bellmouth connection, were built in open cut. The cut was about 26 ft. wide (for the four-barrel work) and had a maximum depth of about 16 ft. This excavation was done with a 1-yd. clam-shell bucket handled by a traveling derrick of special design, shown in Fig. 6.

and the machine operated as a steam shovel. It may be used also as a piledriver, with leads attached to the head of the boom. This machine was built by the C. O. Bartlett & Snow Co., of Cleveland, Ohio, and was designed by R. M. Gates, of that company. Similar machines have been built for other work, some operated by electric motors instead of by steam engines.

ENGINEERS AND CONTRACTORS

The sewer was designed by Robert H. McCormick, City Engineer, Detroit, and Wm. L. Day is the resident engineer in charge. The contract for section No. 1 (the outlet section described above) was let to the John T. Walbridge Engineering Co., of Chicago, and John E. Rowe is the contractor's superintendent on the work.

Rapid Loading of Auto Trucks by means of boxes on wheels, which were loaded at the railway, lifted upon a truck by a crane, conveyed to the job, rolled out upon a wood platform and down a sloping runway to the ground, where they were unloaded and placed empty upon returning trucks, was accomplished by J. F. Kult & Son, Buffalo, N. Y., who hauled all the marble for the new $1,500,000 Catholic Cathedral of that city. The marble totaled about 590 carloads. At first, loading was done by a crane, block by block at the railway, and unloaded at the site by hand. Four 5-ton Pierce-Arrow trucks were used to transport the marble; one truck in a 9-hr. day handled about 50 tons, the round trip being about eight miles.

The Mayo Bridge, Richmond, Va.--A Reinforced-Concrete Municipal Bridge

By C. E. Bolling*

There has recently been completed and opened to traffic at Richmond, Va., a reinforced-concrete arch bridge of ornamental design and pleasing appearance. It crosses James River, connecting 14th St., a congested thoroughfare in the wholesale section of the city at its north end, with Hull St., the main artery of travel through the newly annexed territory lying to the south of the river, known as South Richmond (formerly Manchester). Its location occupies the position formerly occupied by an old toll bridge, which was removed in order to make way for the construction of the new bridge; the site being well adapted to traffic conditions for that part of the city in which it is located. The bridge is just at the head of tidewater, and near the foot of the falls of James River.

Method of Obtaining Design

Tenders were called for "Bids accompanied by Plans" and a subcommittee from Council Committee on Streets was chosen to consider designs. A Board of Engineer Examiners or Consulting Engineers was then appointed, consisting of Wilbur J. Watson, C. P. E. Burgwyn and Chas. E. Bolling, City Engineer, to whom plans were referred for examining, selecting, and recommending the best design.

There were fifteen bidders whose several propositions were referred by the Council Committee on Streets to their Subcommittee and Board of Engineers for report.

The Subcommittee selected five out of the fifteen propositions submitted and referred them to the Board of Engineers, and they in turn prepared a written report as to the character of construction, design, stresses, roadbed construction, vent of river flow, etc., for each design. The committee selected the design submitted by Messrs. I. J. Smith & Co., Inc. The design selected was made by the Concrete-Steel Engineering Co., of New York, and submitted through I. J. Smith & Co., Inc., local contractors, as bidders. The price named to complete the design as selected was $224,734 with amounts given for certain additions and deductions.

The contract was awarded in July, 1911, and the work immediately begun, with a contract time-limit for completion within twelve months from date of contract.

Description of Design

The bridge is divided into two separate divisions by an island, and is 1775 ft. long from shore to shore, including the island. The division north of the island is 587 ft. long and contains seven arches; that lying south of the island is 895 ft. in length and has eleven arches. The island construction between the abutments of the two divisions is 293 ft. in length, and consists of an earth-filled embankment between stone retaining-walls brought to grade and connecting the two sections of the bridge on either side. Inclined entrance roadways lead from the island to the bridge.

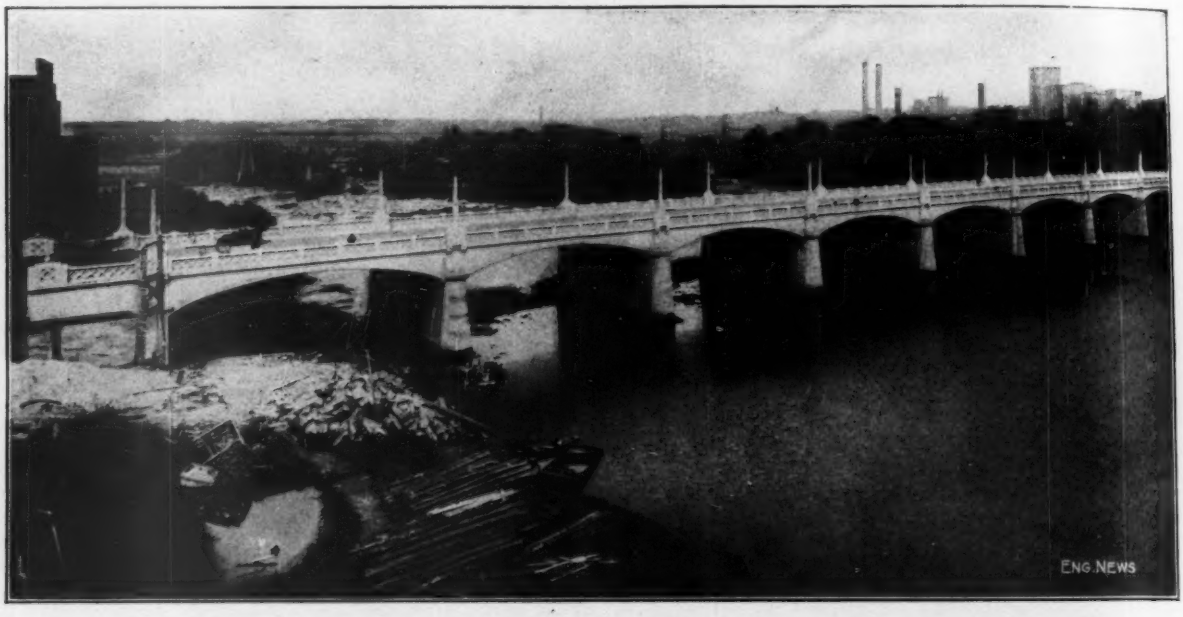


Fig. 1. South Branch of Mayo Bridge across James River, Richmond, Va.

The abutments, piers and arches in both divisions of the bridge are uniform in their respective design, with a total of four abutments, sixteen piers and eighteen arches.

The height of pier from footing course to arch spring line is 21 ft., and its transverse length, measured at the base, is 69 ft. Both ends of the piers are built with semi-circular nosings projecting beyond the line of arch face, and capped with a circular coping 12 in. above the springing line of arch. The width of the pier at its arch intersection is 6 ft., and is battered with a 1 in 12 slope to a width of 9ft. 6 in. at its base, where it rests upon offset footing courses of varying heights and widths—depending upon the depth below neat line elevation to rock foundation.

The arches are notable for their slender proportions and small rise. Each has a clear span of 71 ft. and a rise

*City Engineer, Richmond, Va.

of 7 ft. The crown section is 16 in. deep, except under the street-railway tracks, where it is increased to 18 in. for a width of 18 ft., the extra 2 in. at the crown being added upon the recommendation of the aforesaid Board.

The arch is reinforced with 21 Melan ribs spaced 35 in. on centers, each rib made up of pairs of 2½x2½x¼-in. top and bottom flange-angles laced with 1½x¼ lattice bars. Each frame was bent to the intrados and extrados of arch ring, placed on the work in three sections, and field-spliced near the haunches upon completion of arch falsework.

The spandrel walls are 18 in. thick, except over the skewback of the arches, where they are battered on the back with a slope of 1 in 2½. The walls are capped with a 10-in. overhang coping, reinforced with ⅝-in. horizontal and vertical bars. Six expansion joints are provided within the length of each span, extending vertically from the base of the walls entirely through the coping, parapet and hand rail above.

Pitch and felt were applied in waterproofing the top surfaces of all abutments, piers, arches, and the back of the spandrel walls. Sand and gravel were selected and used in making the spandrel fill. Space is provided under the sidewalks for electric conduits, water and gas mains.

The parapet is composed of a solid concrete wall with posts equally spaced and projecting beyond the diamond-shaped recessed panels, capped with a concrete hand rail 15 in. wide.

Reinforced-concrete light and trolley poles are mounted upon pedestals, built in the line of the parapet walls over both ends and sides of the abutments. The light posts are constructed to carry four lights, supported by brackets and connecting with the light wire under the sidewalk by means of a 3-in. diameter pipe placed in the center of post and pedestal.

The bridge was designed for a floor load of 150 lb. per sq.ft., with double track laid for 50-ton street-railway cars. The roadway is paved with granite blocks laid on a concrete base, is 44 ft. wide between curbs, with granolithic sidewalks 6½ ft. wide on both sides.

FIG. 2. NORTH BRANCH OF MAYO BRIDGE

PLANT

Immediately after the award of the contract, the Contractors began to install their plant, to construct first the North Division of the bridge, between the island and the north shore of the river. Neither space nor conditions were adequate for unloading and storage of material at the northern end of the bridge, while at the southern end ample space was available and conveniently connected with the railroads by a spur track, which was extended over an old foundation pit by the construction of a timber trestle, over which cars of sand and stone were run, and the material was deposited in storage piles beneath. The material used in the construction of the North Division was, therefore, transferred from the south end, by means of the old bridge left standing over the south channel of the river, and used for that purpose until the construction of all arches in the northern division was completed.

Two cables, each of six-ton capacity, were set up and centered 15 ft. either side of the center line of bridge. The towers were 75 ft. high, with a span of about 700 ft., and strung with a 1¾-in. main cable. In reërecting the cableways for construction over the south channel, the span of the cable towers was increased nearly 300 ft., and the towers increased 15 ft. in height.

The concrete mixing plant was also removed from the island to the south side of the river for the construction of the South Division, and, in so doing, many improvements were made, and its capacity increased. Better arrangement was also made for handling the sand and stone, by erecting a stiff-leg derrick with a 60-ft. boom, operating a ¾-yd. clam-shell bucket, which was used to elevate the sand and stone from the storage piles beneath the trestle to bins built above the concrete mixers. Two batch mixers were installed and connected up with

the cable boilers, one of small capacity, and used only in case of emergency; the other of 40-cu.ft. capacity with an average output of 130 cu.yd. per 10-hr. run. Both mixers discharged into bottom-dump buckets set on trucks and run out underneath the cableways.

Construction

The wrought iron in the superstructure of the old bridge was removed by means of the cableways, while the piers occupying practically the same position as those of the piers in the new bridge, were removed by derricks set in the river between and in reach of two piers. The stones from the old piers were lifted out and piled in the chamber between piers until foundation for the new pier had been reached. After concrete work was started, the stones were then placed by the derrick into the masonry of the new pier, without interruption of the cableways handling the concrete. The stones, varying in size from ½ to 16 cu.ft., were embedded into the concrete while pouring, with their surfaces not nearer to each other at any point than 6 in.

All piers and abutments rest upon a foundation of bedrock at an average depth of about 5 ft. below mean tide. The bed of the river at the bridge site is made up of deposits of mud, coarse gravel and boulders of varying depths overlying a strata of rough granite ledge, thoroughly irregular in its surface. The tide, under ordinary conditions, has a range of 4 ft., which assisted very materially in the construction of the timber coffer-dams used in securing the rock foundations.

Uniformity of design in the piers, alike in other parts of the structure, was the means of producing economical form work. For the piers, three complete sets of pier forms were made and used for the construction of all piers. They were built in sections, and made of t. and g. sheeting, nailed to 2x6-in. studs spaced 24 in. c. to c. Alternate piers were anchored by drilling 20 in. below the surface of rock foundation, at intervals of 3 ft. along both transverse faces of pier and 6 in. therefrom. Anchor bars of 1¼-in. diameter were placed and grouted, with every other bar extending up to the spring line of arch, the remainder extending into the pier a distance of 5 ft. above bedrock. The original plans did not provide for this anchorage of piers to bedrock, but was added upon the recommendation of the Board of Engineers.

The concrete of the arches, while pouring, was supported by a simply framed timber falsework.

The concrete for the arch-ring construction was taken from the mixer by cableways and placed in hoppers elevated by bents resting upon the lagging of the falsework at the crown of the arch directly under each cable. From the hoppers the concrete was distributed to any point over the arch by adjustable chutes.

Concreting was started simultaneously at the skewbacks, bringing up the full depth of the ring by continuous pouring and closing in at the crown with uniform and symmetrical loads placed upon the centering. In closing in at the crown section, the hoppers were so arranged as to be quickly removed, and the concrete placed directly from the bottom-dump buckets lowered into the concrete, and deposited without impact upon the falsework.

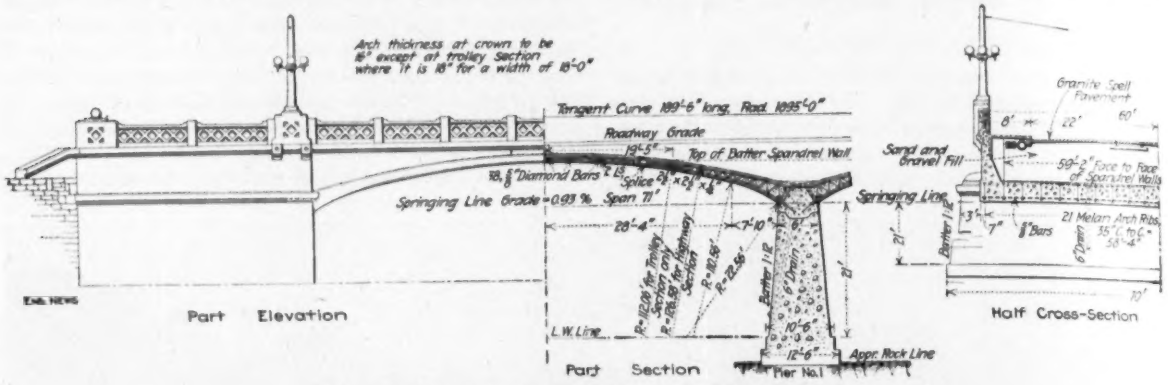

Arch thickness at crown to be 16" except at trolley section where it is 18" for a width of 18'-0"
Tangent Curve 189'-6" long, Rad. 1035'-0"
Roadway Grade
Top of Batter Spandrel Wall
18 1¼" Diamond Bars
Springing Line Grade - 0.93 %
Span 71'
Part Elevation
L.W. Line
Appr. Rock Line
Pier No. 1
Part Section
Granite Spall Pavement
Sand and Gravel Fill
Springing Line
21 Melan Arch Ribs
1" Bars
Half Cross-Section

FIG. 3. DETAIL OF TYPICAL ARCH OF MAYO BRIDGE

Three-inch strips were placed on the top flange of steel ribs, and used as gages to determine the necessary thickness of concrete in the arch ring and above the steel reinforcement. The concrete was spread to conform to the extrados of arch as marked by the strips, and after removal of these, a trowel was used to produce a smooth surface in preparation for the waterproofing.

Prior to the pouring of the concrete, level readings were taken over the lagging of falsework vertically above each of the wedges and the flooring of the arch adjusted to conform with its true position shown on plans, with an extra rise of 1½ in. made at the crown section and feathered out at the haunches, for compression of timbers and settlement of centering. Each pile support was carefully observed for settlement while pouring and upon loading of centers, with elevations taken to determine the amount of deflection of arch ring under load of spandrel fill and after removal of falsework. Such data were recorded and filed on forms printed for that purpose.

The falsework was not removed from underneath any arch in less time than four weeks from date of pouring.

Each arch contains 280 cu.yd. of concrete, which was equivalent to 22 or more hours' run at the mixing plant. The first seven arches were thus poured as a monolith for their full width of 59 ft. 6 in., but the remaining eleven arches (those in the South Division), were divided in half by a bulkhead placed parallel to the center of the bridge, extending from skewback to skewback, and built for the full thickness of the arch. Both hoppers, placed as they were in pouring the full width of the arch, deposited concrete in this half of the arch in less than one-half the time required for pouring the full width, the concrete more economically handled and better results in the work obtained through the elimination of long hours, shifting of force and night work.

The spandrel walls and coping over same were poured in alternate sections, with strips of tarred felt placed between them to provide for expansion. Forms were built of 1⅞-in. t. and g. stock, braced on the outside against 12x12-in. timbers carrying the arch joist and left projecting for this purpose. The front and back forms were tied with ¾-in. bolts, passing through outside horizontal waling pieces and connected by sleeve nuts, left in the body of the concrete after drawing the bolts and removal of forms.

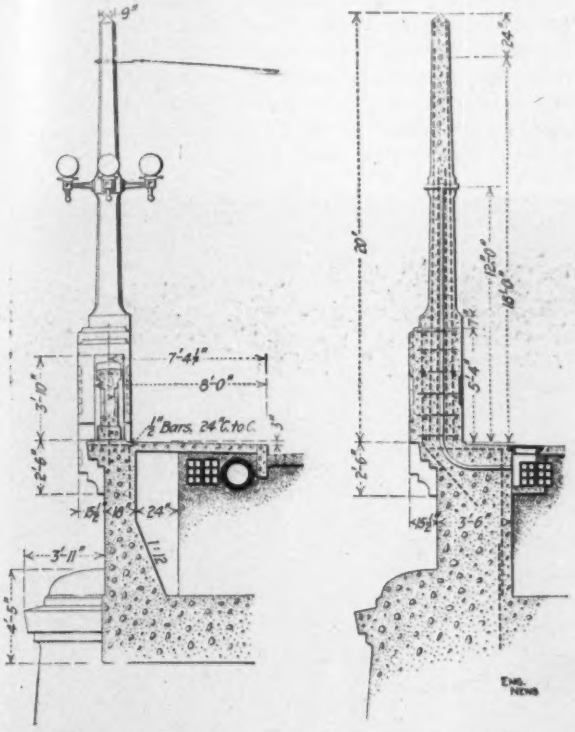


FIG. 4. REINFORCED-CONCRETE LIGHT AND TROLLEY POLES FOR MAYO BRIDGE

The parapet walls, like those of the spandrel, were poured in alternate sections.

REINFORCED-CONCRETE POLES—The light poles were cast with a mixture of 1:2 cement and granite screenings, poured in forms placed horizontally, and allowed to remain from three to five days, when the forms were removed, and the surface of the concrete rubbed with carborundum blocks. After seasoning for at least 30 days, the poles were erected in position by an A-frame setting derrick, the pole being suspended from a bar passing through the 2-in. pipe-cross connection, 8 ft. from the top, placed for wiring and attaching the light brackets. With the pole lined and held safely in position, the pedestal forms were then set and concrete poured, anchoring the pole to the supporting pedestal by incorporating the reinforcing bars left projecting from the base of pole.

The grade of concrete used in various parts of the structure was as follows: One part portland cement, three parts sand and six parts (3-in.) crushed stone in foundations, piers, abutments and spandrel walls. For the arches, copings, parapet walls and handrailing, a mixture of 1:2:4 was placed, using 1½-in. stone.

Careful attention was given toward the treatment of exterior surface of the concrete for bridge finish, which was obtained for the abutments, piers and underside of arches by the use of smooth-faced forms and thorough spading. In addition to the above, a carborundum rub was applied to the surface of all arch faces, pier caps, copings and spandrel walls, the latter by removing the forms while the masonry was still quite green. In the treatment of the parapet surface, a contrast was produced by sand blasting the wall and hand-rail sections and rubbing the pole pedestals to a smooth finish with carborundum. The top of the hand rail was troweled to a granolithic finish.

COSTS

The total cost, not including right-of-way, was $267,287.90, and including approaches, $281,000. This covers 30,000 bbl. of cement, 23,500 cu.yd. of concrete and 400 tons of steel.

PERSONNEL

The bridge was erected under the supervision of C. E. Bolling, City Engineer, M. O. Hankins, Assistant City Engineer, and G. M. Bowers, Resident Engineer. The Concrete Steel Engineering Co., of New York, was the Consulting and Designing Engineer. The contractor was I. J. Smith & Co., Inc., of Richmond, Va.

Oiled Macadam Roads in California Not An Unchallenged Success—This type of paving is peculiar to the localities producing an asphaltic oil. There is no fixed specification for its construction, but it is laid under many different ones, according to the whims of the engineer in charge. The name covers all classes of road surface in which oil is combined with road metal as a binder. The usual method of construction is to lay the road metal and roll the various layers in the same manner as for water-bound macadam, applying to each layer by a sprinkler a certain specified quantity of asphaltic road oil. In constructing this pavement, the main difference of opinion among road builders is in regard to the quantity of oil to be applied.

As a matter of fact, a very small proportion of the total area of oiled macadam pavement constructed has been successful. Under heavy traffic it ruts and waves very badly. It is my opinion that, even under the best conditions, this pavement has little justification. Oil has more lubricating than binding properties, and its introduction into a macadam pavement has a tendency to destroy the stability of the metal. The successful examples of pavements of this class have been either in localities where climatic conditions are such as to evaporate the more volatile parts of the oil, or where the application has been made in such a manner as to achieve the same result. Oiled macadam roads which have become so rutted as to be almost impassable, have been converted into fairly good pavements by scarifying and rerolling, thereby aërating the oil and causing the evaporation of the lighter constituents. [William C. Hammatt, M. Am. Soc. C. E., Consulting Engineer, San Francisco, Calif., in a paper "California Highway Construction," April "Proceedings of the American Society of Civil Engineers, p. 919.]

Oiled Macadam for Pavements in Residence Streets—For residence streets, Oakland, Calif., is using exclusively some type of oil-macadam. The oil-macadam heretofore most generally used consists of the ordinary amount of macadam rock (6 in. deep at the gutter and 8 in. deep at the crown, measured before rolling) compacted and treated with two applications of heavy road oil, aggregating 1½ gal. to the square yard. The amount of oil is sufficient to produce an oil-bound surface of about 3 in. in depth. This type of pavement requires careful workmanship, particularly in the matter of securing a pavement firm enough to carry heavy loads and at the same time sufficiently porous to admit the oil. With the widely differing character of the stone in common use, the daily changing weather conditions and the disagreement among experts as to the proper method of building oil-macadam streets, this attempt to build a two-course macadam in one operation has been a serious problem. Results have generally been good, in many cases ideal, and in a few cases defects have developed. [Annual report of the Commissioner of Streets of Oakland, Calif.]

Special Shopwork on the Heavy Members of the Quebec Bridge

By H. P. Borden*

SYNOPSIS—Steel fabrication of unprecedented kind is involved in the construction of the new Quebec Bridge. Among the factors are: Metal thicknesses over 9 in., 1⅛-in. rivets, nickel steel, great weight of parts and of completed members, drilling from solid for nearly all rivet-holes, planed faces up to 10x20 ft., 45-in. pin-holes. The equipment and shop methods are described. Large detail photographs illustrate the account.

During the past fourteen months, the fabrication of members for the new Quebec Bridge has been steadily going ahead at the shops of the St. Lawrence Bridge Co. near Montreal. As an entirely new plant was built and new machines constructed for this work, the contractors were compelled to face the problem of initiating the construction of a bridge whose members have no equal in bridge construction at the present day, with an untried equipment and a brand new organization. The difficulties of constructing ordinary bridge or structural work under similar conditions would be apparent, but when there is coupled to these conditions the unprecedented size of the members and the unusually stringent specification governing the work, it can be seen that the difficulties were very considerably augmented.

Fortunately, the contractors were able to first put through the shops the floor system, which is considerably simpler than the truss members and therefore served to get the organization in running shape. The floor system for the anchor and cantilever arms, for both sides of the river, has all been manufactured and shipped to the site, and since the first of the year a definite start has been made on the fabrication of the huge members which go to make up the North Anchor Arm.

One of the Great Shoes of the Quebec Bridge, Assembled in the Shop for Fitting and

*Assistant to Chief Engineer, Board of Engineers, Quebec Bridge, Montreal.

Plant and Machinery

In order to adequately cope with the difficulties involved in the manufacture of this steelwork, it was necessary to equip these shops with machinery and handling facilities of, in many cases, unprecedented size, capacity and accuracy. This includes machine tools for precise work in finishing bearing surfaces up to 10 ft. square, boring machines capable of boring pin-holes (in compression members) up to 48 in. in diameter, and a planer capable of surfacing castings or bed plates 30 ft. long and 10 ft. wide.

The shop itself (Fig. 4) is 660 ft. long, 160 ft. wide for 440 ft. of its length and 190 ft. wide for the remainder.

The main shop has one row of columns down the center, the remainder of the space being clear of posts in order that material could be handled with the least amount of difficulty. Material is handled in the receiving yard by two 7½-ton trolley hoists on a 15-ton electric traveling crane with 90-ft. span on runways 500 ft. long. Material entering the shop passes consecutively through the edge planers, shears, drilling tables, etc., to the punching and riveting machines. From this point it branches to the assembling skids, the heavier members going to one side of the shop, which is equipped with two 70-ton electric traveling cranes, while the lighter material goes to the other side, equipped with two 35-ton electric cranes. The latter is intended for members weighing 70 tons or less; the former is capable of handling the largest members to be fabricated, some of which weigh about 190 tons. This means that the two 70-ton cranes are at times compelled to take considerable overload, but it is found that they are capable of handling these heavier members with little or no difficulty.

Many members in this bridge must, on account of their size, be shipped in a number of pieces. This means in most cases that the various parts of one member have to be fabricated and machined with entirely separate operations and riveted together in the field. In order to guarantee that these several parts will go together as designed, extreme precautions are necessary in their fabrication. With this in view, the specification for this bridge has been prepared with unusual care with the idea of obtaining results consistent with the best known shop practice.

Planing and Facing of Material

According to the specification *all sheared edges shall be planed,* at least ⅛ in. being removed.

Long plates are planed on two heavy machines with a capacity of 46 ft. in length. The planing of sketch plates is done on a similar but considerably smaller machine. The plates are held in position on the table by pneumatic clamps, which operate very quickly. The tool carriage travels the length of the planer, carrying the operator, and cuts in both directions. The ends of universal plates, and angles are planed on twin milling machines by which both ends are faced simultaneously, finishing to the exact length. In this machine, it is possible to fasten six or eight plates or angles together and mill them at the one time.

The ends of stiffener angles are faced on a special machine which grinds one edge to fit the fillet of the flange angles. Small material, such as connection angles and small lattice bars, is usually ground on an emery wheel. Heavy lattice bars whose ends are cut to different angles, go to a special machine which mills these two faces simultaneously.

Punching, Reaming and Drilling

According to the specification, all material $\frac{11}{16}$ in. and under may be subpunched and reamed, while thicker material must be subdrilled and reamed or else drilled from the solid. As the minimum thickness of material allowed in main members is ½ in., and a large proportion of the material considerably exceeds that thickness, most of the work is drilled. The shop has the usual equipment of punches as well as an automatic multiple punch, yet chief attention naturally was paid to the equipment of drills and reamers.

The drilling plant includes 16 heavy stationary radial drills mounted on a long foundation at the center of the shop and parallel to its axis, and 24 similar portable drills each mounted on an individual truck traveling on a portable track which can be clamped to the concrete floor. All the drills have 6-ft. arms with vertical adjustment and have locking devices for attaching them to the track. Variable-speed motors furnish the power. There are also 12 horizontal drills mounted on trucks to work in connection with the radial drills and for use in drilling field splices in main members.

According to the specification all reaming and drilling shall be done *dry,* without the use of water or other lubricant.

A long series of tests has been made by the shop on high-speed tools without lubricant, and while it was found there is no serious difficulty in drilling plates of moderate thickness, yet considerable difficulty has been met when thicknesses of 4 in. or more are to be drilled. This is especially true in the case of nickel steel. At the present time, the shop is using a thick red-lead paste with which the tool is painted during the drilling of thick plates, and it is found that this works very efficiently and has not the objectionable features that are found with either water or oil.

As a rule, three sizes of rivets are used, namely, ⅞ in., 1-in., 1⅛ in. With these machines it is found possible to drill a $1\frac{5}{8}$-in. hole at a feed of 3 in. per minute; $1\frac{3}{16}$- and $1\frac{3}{16}$-in. holes are drilled at about the same rate.

A large proportion of the drilling is through exceedingly thick material, made up of a number of plates or angles. On the bottom chords, the thickest material is through the splice-plates of the chord next the shoe, where the rivet-grip amounts to 9⅞ in. The connection at the top of the main post has a maximum thickness of 7 in. of nickel steel.

In assembling the webs of the chords, tack holes are subdrilled in the plates and angles for the purpose of assembling, after which the full-size holes for shop rivets are drilled from the solid. Field connections are either subdrilled, and reamed after the member has been assembled in the shop, or are drilled full size to a steel template.

As misdrilling or mispunching on these very big members may prove very costly, all center-punch marks for drilling are *encircled in white paint or chalk* so that the chance of error is reduced to a minimum.

Where a steel template is used the specification calls for a plate at least 1 in. thick. In practice, however, it has been found that a template ¼ in. thick, having the holes fitted with hardened steel bushings 1 in. high, gives better results, as the hardened steel tends to prevent any drifting of the tool should the subpunched or drilled hole be somewhat irregular.

Special attention is paid to keeping the several parts of a member thoroughly bolted up while being drilled in order to prevent filings entering between the various thicknesses of plates. This is satisfactorily effected by staggering the holes when drilling and following up immediately with bolts.

Facing the Ends of Complete Members

Probably the most carefully watched work in the shop is the facing of the compression members and the boring of the pin-holes.

The main bottom-chord members, measuring 10 ft. by

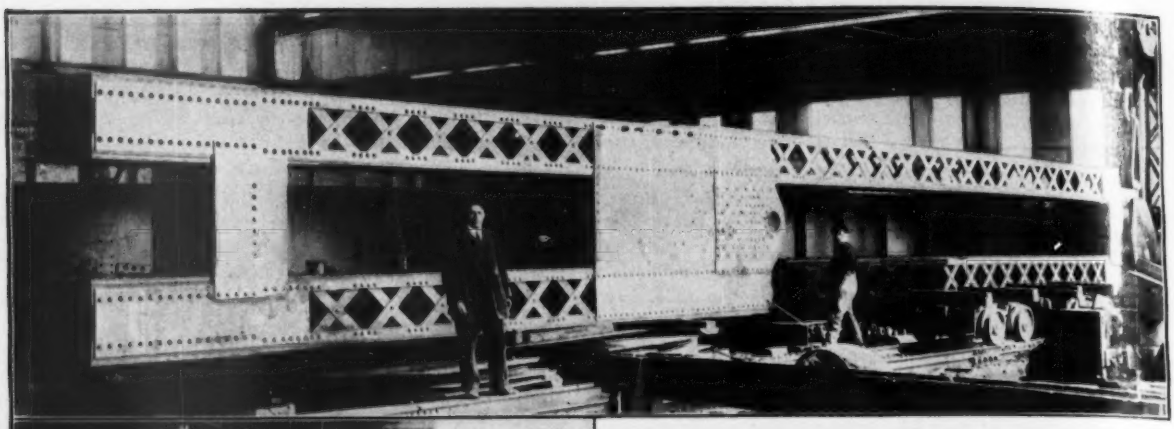


FIG. 1. VERTICAL TENSION-MEMBER AM6-L6, READY FOR SHIPMENT

(The pin-hole at the middle takes the pin which supports the floor-beam, whose two webs extend past the post either side.)

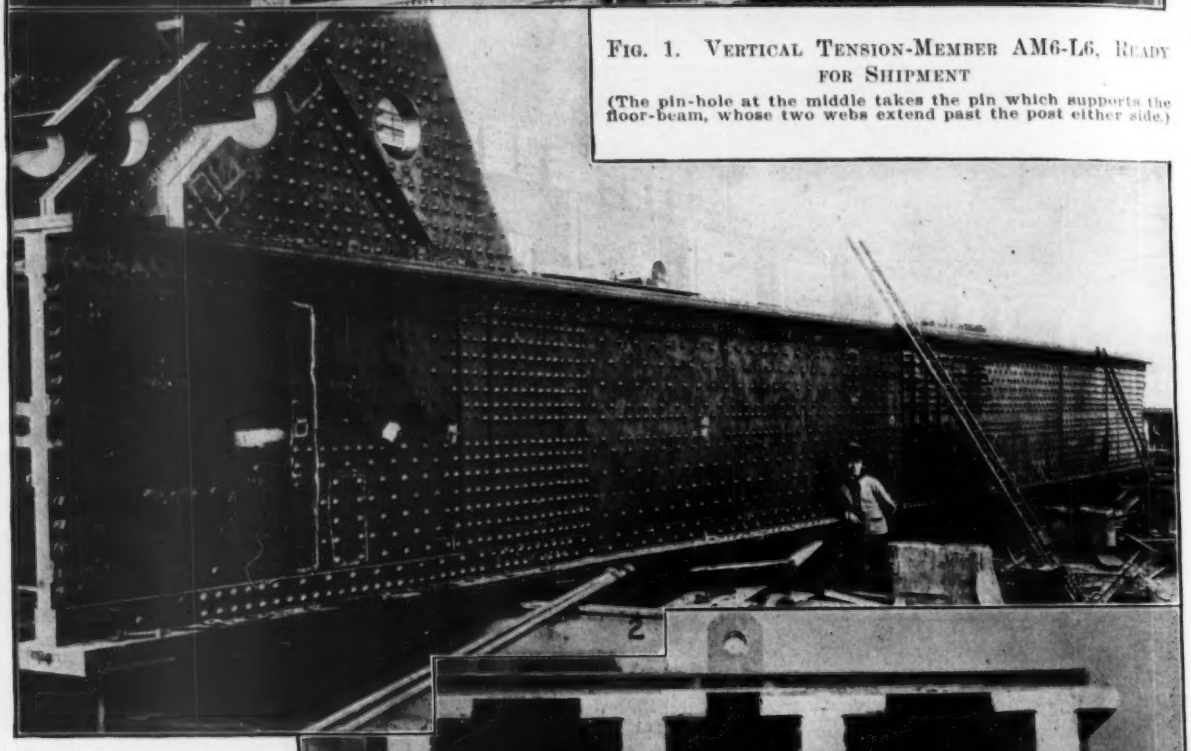


FIG. 2. BOTTOM CHORD AL12-AL14 ASSEMBLED FOR REAMING OF FIELD SPLICE

(This is the full panel-length. It is shipped and erected in four pieces, spliced longitudinally between the two inner ribs and transversely at mid-length.)

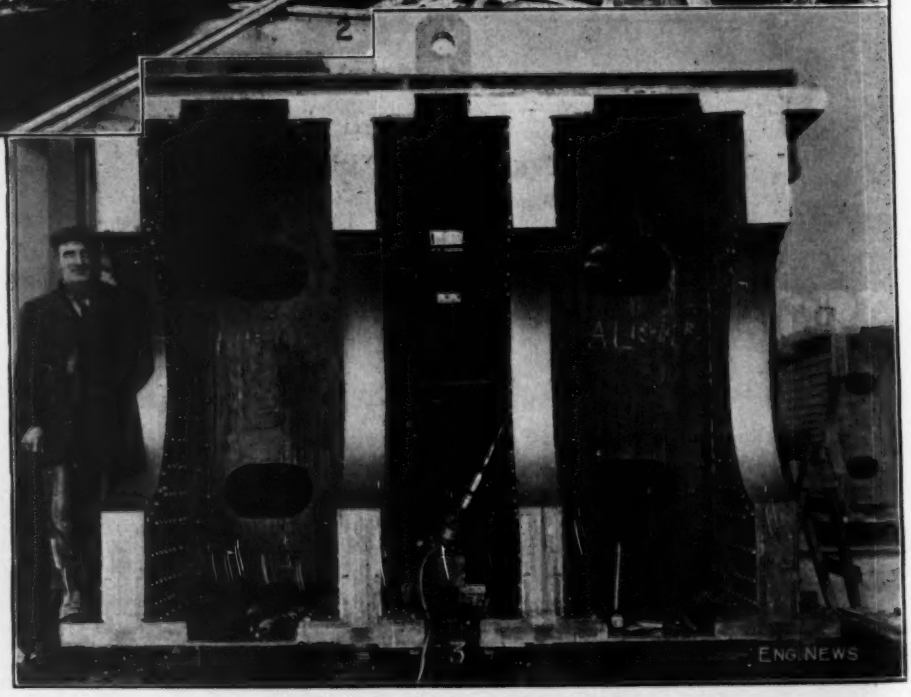


FIG. 3. FORTY-FIVE INCH PIN-HOLE IN PIER END OF BOTTOM CHORD AL12-AL14

(The 45-in. hole takes a cast-steel bushing, in which a 30-in. pin is seated. This view shows the far end of the member pictured in Fig. 2.)

THE QUEBEC BRIDGE IN THE SHOP

7 ft. in outside dimensions, are faced in a duplex vertical and horizontal planing machine which is capable of facing both ends of the chord simultaneously. One of the machines is stationary, the other is movable to any position on a 25x75-ft. bed. The heads of these machines can make a 10-ft. cut in either a vertical or horizontal direction and are equipped with patent tool holders for cutting on both direct and return strokes.

The operation of setting a chord member in the correct position in the machine is a somewhat delicate and laborious one, taking from one to two days to accomplish. As the chords are tapering in a vertical plane, the difficulty of setting their center line true is increased. The practice is to determine this center line on the web of the member by numerous measurements and drive a tapered pin in ⅛-in. holes bored exactly on this center line; on these pins, used as benchmarks, the horizontal position of the piece can be ascertained by means of a field level. The greatest care is taken by numerous checks and rechecks to make absolutely certain that the member is in its true theoretical position before any work is done.

On the first chords that were milled, the planing was effected by making the roughing cut on the downward stroke of the machine and the finishing cut on the upward, thus finishing the milling when the machine had traveled completely across the member. This method was found to be not entirely satisfactory, as it took five days to make one cut across the member, and changes of temperature in consecutive days would be liable to affect the length materially. In one case, the length was so seriously affected that the member had to be refaced. The present practice is to face the end first with the roughing cut, the machine feeding both on the up and down stroke, and then going completely across the second time with the finishing cut with a little faster feed. By this means, each operation can be completed in from 15 to 20 hours. In order to ascertain whether there has been any wear or give of the tool, the machine is run across the face after it has been finished and the distance between the tool and the end of the member determined by means of "feelers." From 0.001-in. to 0.004-in. variation from a true surface is the maximum that is generally detected in this way.

Smaller members, such as the tension verticals and other members which do not take end bearing, have their ends milled on the rotary facing machines.

Planing the Shoes

One of the most laborious planing operations is the facing of the enormous steel castings which form the first story of the shoe. These castings are 20 ft. 10 in. by 6 ft. 8 in., and 4 ft. high, and weigh approximately 40 tons each. There are four of these castings under each shoe. Their webs, flanges and interior diaphragms are from 2½ in. to 3 in. thick. These castings are planed on a large planing machine designed especially for this work, in which the cutting tool has a travel of 10 ft. transversely and 30 ft. longitudinally. The castings are faced top and bottom and all four sides. There are two cutting tools fitted on the horizontal crosshead, so that the operator is able to start one tool from the center of the casting and the other one at the edge, reducing the time of the total operation by one-half. The finishing cut, however, is done with one tool across the entire face of the casting. It requires about 20 hours for a single tool to make one entire cutting.

The sides are planed without turning the casting on edge, by a cutting head on each side attached to the vertical head of the machine.

Under fair conditions, it takes about two weeks to completely plane one of these castings. As there are sixteen required, this operation alone requires from eight to nine months' continuous work.

On the first one or two castings that were finished it was found, on checking them up, that while the ends were exactly to gage there seemed to be a slight concavity near the center, in one case amounting to nearly $\frac{1}{32}$ in. Exhaustive tests were made on the machine to determine how this could have occurred, but no explanation could be arrived at except release of internal stresses in the casting when the outer crust had been removed by the cutting tool, thus causing a slight warp. To guard against such contingency, it is now the practice to finish one face, leaving about $\frac{1}{16}$ in. for the final cut, then turn the casting over and completely finish the opposite face. The casting is then again turned and the final cut made on the original face. It has been found that much more satisfactory results have been obtained by following this program.

Boring Pin-Holes

The boring of the pin-holes and half pin-holes in the gusset-plates of the chords and in the shoes is performed on a large boring mill which has a boring capacity up to 48-in. diameter, with a longitudinal motion of 23½ ft. and a vertical motion of 15½ ft. The vertical arms carrying the crosshead and boring bar travel on a steel bed embedded in concrete and are operated by a rack and pinion geared to an electric motor. When the member is once assembled in its proper position on the bed of the machine, it is therefore not necessary to move it until all the holes are bored. In such an operation as boring the shoe, where there are five distinct pin-holes, these holes can be drilled without moving the member, thus assuring that all holes are absolutely parallel and at right angles to the vertical and longitudinal axes of the member.

The largest half pin-holes to be bored are those at the end of the bottom chord and in the shoe, which receive the 45-in. cast-steel bushing which in turn takes a 30-in. pin. There is also the same size of pin and bushing on the top of the shoe which takes the reaction from the main post.

The pin-holes in the smaller tension and compression members are bored on the twin boring machine on the other side of the shop. Pin-holes in members up to 100 ft. long center to center, can be bored simultaneously on these machines. When it occurs that members exceed this length, as is the case with a number of the members, it is necessary to bore each end separately, making a separate adjustment of the member itself for each operation.

The boring of the pin-holes in eye-bars is performed on another special eye-bar-boring machine, which bores the holes in both ends of the eye-bar simultaneously. The pin-hole is $\frac{1}{32}$ in. larger than the normal diameter of the pin, plus 0.01 in., which is allowed for wear of tool. In order to minimize the chance of error from undue wear of the tool, only one eye-bar is bored at a time. The specification requires (as customary in other bridgework) that when the bars for one full panel have been bored they shall be placed one upon the other and the pin shall

be required to pass through the holes at both ends at the same time without difficulty.

In order to facilitate erection and offset the possible effects of settlement of the falsework and the deformation of the web members under their own weight, pinholes in both ends of the top-chord eye-bars, and in the upper ends of tension diagonals of the anchor arms, are bored oblong to the extent of ½ in. As there are two lengths of eye-bars in each panel, this means there is a possible adjustment of 2 in. in each main panel of the top chord. The back-to-back spacing of these oblong pin-holes corresponds in each case to the calculated length of member as designed to take care of the final camber, the elongation of the hole being toward the center of the member.

As this detail is somewhat unusual in bridge practice, a series of tests was made by the St. Lawrence Bridge Co., at Ambridge, Penn., to determine the relative elongation of eye-bar heads with oblong and round holes. Tests were made on six bars having a round hole at one end and an oblong hole at the other. Readings were taken on these bars for a distance of 3 ft. from the back of each pin-hole. It was found that under a load of 20,000 lb. per sq.in. the elongation and permanent set in the oblong heads was on an average greater than that on the other end by about 0.004 in. and 0.002 in., respectively. Under a load of 28,000 lb. per sq.in., the elongation and permanent set at the oblong heads were greater by 0.016 in. and 0.0111 in. respectively. As all the bars broke in the body, it is considered that the results were satisfactory, the difference in results found in the two heads being practically negligible.

Assembling

The specification requires that all field splices in chord and web members shall be assembled in the shops and reamed in place. The operation of assembling the sections of the main chord is a very long, laborious task. As these members have four webs, with horizontal diaphragms between outer pairs, it means there are twelve separate sets of splice plates to be attached to the webs in addition to four sets to be attached to the horizontal diaphragms (which are figured as cross-section in the member). In order to facilitate handling, these splice plates, which are made up of several plates, are tack-riveted together with a countersunk head in the inner face in order that each may be handled in the field as one piece. In addition to these, there are two heavy tie-plates top and bottom.

Although these joints have been designed with 100% riveting, every effort is made to bring the two faces of the chords to a bearing fit before the joints are reamed. It is the practice to drill the splice-plate full size from a template, and to do the same with the webs on one side of the joint. The splice-plates can then be bolted securely up to one half-section of the chord while the other half is held in place by about 10% of tack bolts. When the joint has been satisfactorily assembled, the remaining holes in the webs are drilled from the solid, using the splice-plate on one side as a template. All splice-plates and other loose plates are then matchmarked with steel dies before being taken apart, to insure their being put back in the field in exactly the same location.

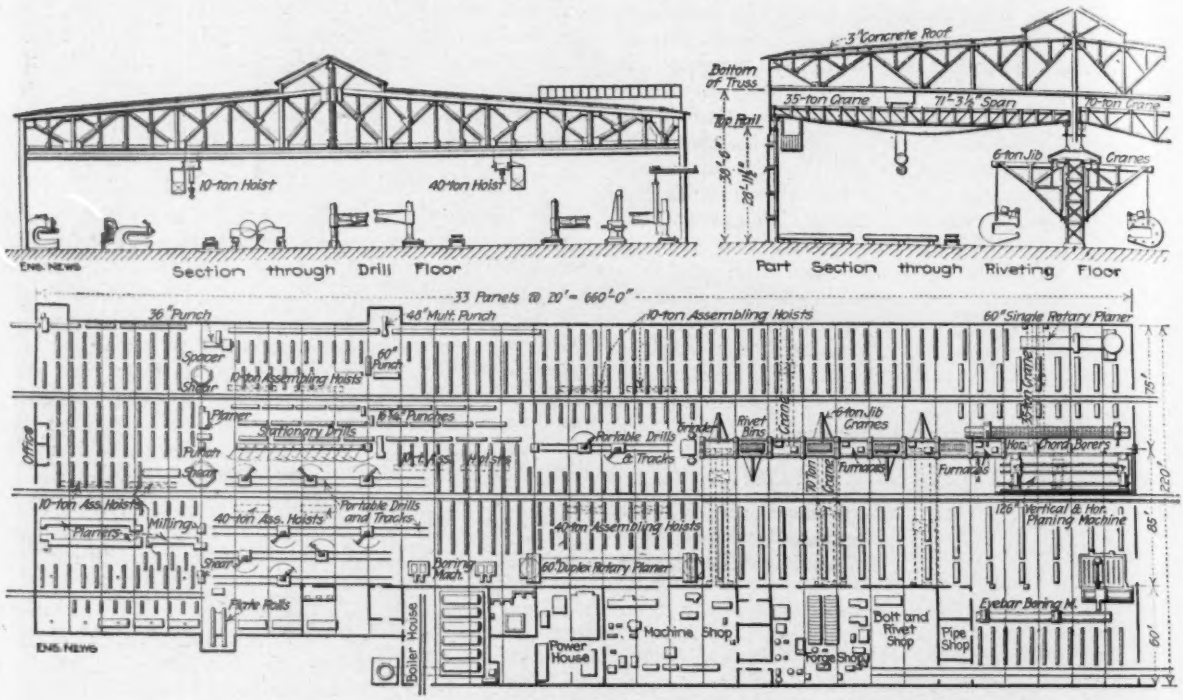


Fig. 4. Plan and Sections of Shop for Fabrication of Quebec Bridge

Riveting

All rivets for both field and shop are of carbon steel. As already mentioned, three sizes are employed, viz.: ⅞-in., 1-in. and 1⅛-in., the diameter being determined by the grip.

Both in shop and field, all rivets are required to be heated in oil furnaces, and special precautions are taken to prevent burning and scaling. Rivets are driven by pneumatic yoke machines with gaps of from 24 to 72 in.,

FIG. 5. REAMING AND DRILLING THE WEB OF A FLOOR-BEAM WITH THE PORTABLE DRILLS

FIG. 6. BORING THE PIN-HOLE IN GUSSET-PLATES OF A BOTTOM-CHORD SECTION
(Faced end of chord, for splice.)

FIG. 7. FITTING THE SPLICE OF BOTTOM CHORD
(Two drills are at work drilling the splice rivet holes.)

THE QUEBEC BRIDGE IN THE SHOP

handled by 6-ton jib-cranes traveling on runways 180 ft. long on both sides of the center row of columns. For riveting in restricted spaces, hand riveters and pneumatic buckers-up are used. Air is delivered to the riveters under a pressure of 80 lb. per sq.in. The large yoke machines have a capacity of 100 tons.

When very thick material is to be riveted, it is found that the best results are obtained by dipping the end of the rivet in water for a few seconds, thus hardening the end slightly. This causes the rivet to be thoroughly upset in the rivet-hole before the head is formed. All rivets over 5 in. long are tapered $\frac{1}{16}$ in. in 12 in., which makes practically a driving fit at the shank. The result is that, as a rule, remarkably tight rivets are obtained. When loose rivets are found, the heads are not sheared off, as is the usual practice, but are drilled off by means of a flat cutting-tool having a hollow core slightly smaller than the shank of the rivet. The upset portion of the head is consequently cut entirely away, leaving the shaft, which is then driven out. By this method, the hole is not distorted in any way.

Pins

About 1480 tons of pins are employed on the whole bridge. Their sizes vary from 8 in. to 30 in. In order to facilitate erection, double pins are used at the connections of all members having four webs, as well as for the top-chord eye-bars, each pin extending over half the width of the member. Each of the 30-in. pins weighs approximately 6 tons. Both nickel and carbon-steel pins are used depending upon the location. These pins are being forged and turned at the plant of the Bethlehem Steel Co. The specification requires that the finished pin shall not vary more than 0.001 in. from the true diameter.

Painting

The specification requires that all plates riveted together in the shop shall be given one coat of iron oxide and shall be allowed to dry before they are essembled. The shop coat is pure red lead to which is added 4 oz. lampblack to 30 lb. red lead, and mixed with pure boiled linseed oil to the proper consistency.

Each member is weighed individually before being stored, and the weight painted on in plain figures.

Mr. W. P. Ladd is works manager for the St. Lawrence Bridge Co. in charge of this work.

The Board of Engineers have their own staff of inspectors both in the mills and shop, and every stage of manufacture is very carefully followed.

Tests of the Electrolysis of Sewage at Toronto

By I. H. Nevitt*

During the fall of 1913, experiments were conducted at Toronto to determine the action of electrolysis on the sewage of that city. Although the results obtained were not such as to warrant the adoption of the process at Toronto, they are worthy of public record, especially in view of the limited available data on the electrolytic treatment of sewage.

The flume used at Toronto was copied from that in use at Oklahoma City,† with the exception that the width was made 12 in. instead of 22. This affected the number of plates in each grid, which had to be reduced to 13.

The plates were 10x24x$\frac{3}{16}$ in., bound on top by copper strip riveted to the iron, and were spaced $\frac{5}{8}$ in. apart. They were held together by four $\frac{1}{2}$-in. rods, the bottom two of which were insulated from the plates by rubber tubing; the other two acted as conductors. The 13 grids were connected in parallel across two copper busbars, running along the sides of the flume. One of these bars had disconnecting switches which permitted two grids being thrown in at once.

Current was obtained from a Westinghouse motor-generator set designed for 250 amperes, at 125 volts. It was connected through a water rheostat to the terminals of the busbars. In the experiments, the amperage was kept at about 250 amperes, while the voltage at the generator was about 9. The voltage at the flume varied from 3 to 6.

The experiments were run at various rates of flow, and for different lengths of time, one being for 24 hr. at the rate of 120,000 U. S. gal. per day. The minimum rate was 84,000 U. S. gal.; the maximum, 156,000 U. S. gal.

The chlorinated sewage was pumped from the high-level intercepting sewer, after having passed through $\frac{1}{2}$-in. screens. This sewer carries about four-fifths of the sewage of the city but does not contain very much trade-waste, although its reaction is slightly acid.

The discharge from the pump flowed through a baffled U-shaped forebay and on through the flume, and was measured at the discharge end of the flume over a weir without end contractions. A bypass weir was provided at the forebay to take care of the surplus sewage pumped.

In the first experiments, it was found that a surface film of sewage flowed through the flume without treatment. This was overcome by placing baffles between the grids, which reached about 2 in. below their top.

Samples of the raw sewage and of the effluent were taken about every five minutes and were sent to the laboratories of the Department of Health to be examined for reduction in solids and bacteria.

On starting an experiment, the bubbling action began slowly and gradually increased. In the course of a few minutes, a scum began to form on the surface of the sewage which got thicker as time passed. It was composed of a frothy mass containing a good deal of iron. Sludge also settled out in the bottom of the flume.

The flowing-through period was about five minutes. The effluent had a more or less rusty appearance, which was very noticeable if the flow stopped at all. The milky appearance which is described as typical of this method was not noticed until a trough was placed at the discharge end of the flume, and the effluent allowed to run about 30 ft. further. It then formed about 10 ft. below the weir.

The examination of the samples was for total solids, suspended solids and bacteria in the raw sewage and effluent. A further examination was made for solids after a sedimentation period of two and one-half hours. A table of typical results follows:

BACTERIAL REMOVAL PER C. C. AT 37° C. AFTER 24 HOURS

Dec. 1	Total bacteria agar	Red colonies bile salt agar
Raw sewage chlorinated	6,600	325
Electrolyzed	5,900	780
Electrolyzed 8 minutes	790	71
Dec. 3		
Raw sewage chlorinated	685,000	21,000
Electrolyzed	77,000	900

*Assistant Sewer Engineer, City Hall, Toronto, Ont.

†See "Eng. News," Mar. 21, 1912.

REMOVAL OF SUSPENDED MATTER

	Untreated	Treated		Per cent. suspended solids removed
Dec. 4				
Total solids	950	980		
In solution	530	740		
In suspension	420	240		43
	After standing 2½ hours			
Total solids	880	800		
In solution	780	750		
In suspension	100	50		50
Per cent. removal	76.2	79.2		
	Untreated	Treated	Treated and settled	
Dec. 12				
Total solids	1170	990	870	
In solution	620	630	630	
In suspension	550	360	240	38
	After standing 2½ hours			
Total solids	820	850	850	
In solution	690	640	630	
In suspension	130	210	220	
Per cent. removal	76.3	41.7	8.4	

Dr. Nasmith, Director of the Laboratories of the Department of Public Health, states, in regard to his examination of the samples sent him, that the sample of raw sewage, after standing 2½ hours, deposited 71.6% of the capable-of-settling solids, while the samples subjected to the electrolytic action deposited only 41.6% of the capable-of-settling solids after a similar period. He states further that "a considerable amount of solid matter was carried up by the gas bubbles, given off from the plates, and held as a scum on the surface. This would largely account for the difference between the two series given above." The bacteria destroyed averaged less than 50%.

All the samples of effluent were putrescible in 24 hours, as shown when tested with methylene blue at 80° F.

It is evident, then, that electrolysis for Toronto conditions is not a success, though a very striking feature of the process is the absolute disappearance of odor from the sewage after passing through the flume.

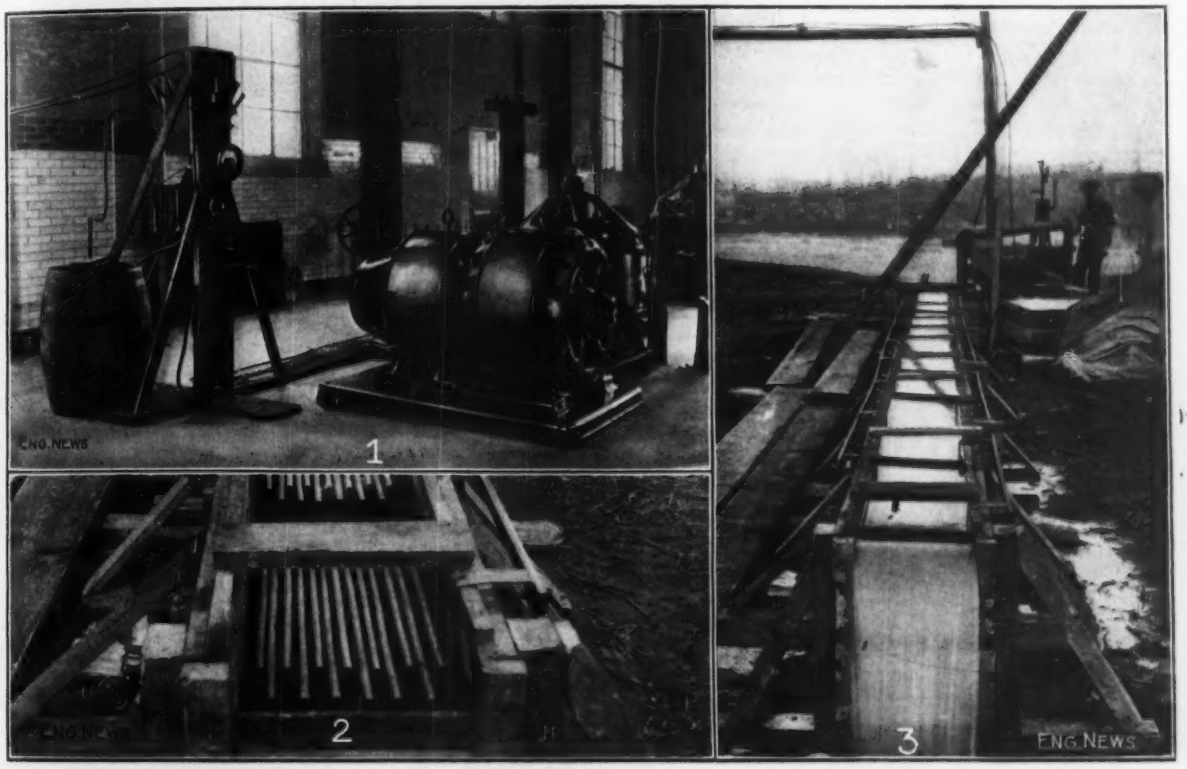
Time	A.c. volts	A.c. amps.	D.c. volts	D.c. amps.	D.c. bus bar volts	Millivolts
12.20	2400	3	9	215	5	39.5
1.00	2400	3	9	270	5	53
1.30	2400	3	9	270		
2.00	2380	3	9	265	5	51
2.30	2390	3	9	250		
3.00	2390	3	9	265	5	6
3.30	2390	3	8	245		
4.00	2390	3	8	270	4.5	52.5

Load on at 12:20 p.m.; shut down at 4:10 p.m.

In cleaning the flume after one set of experiments a sample of sludge was taken, and although kept over a radiator for more than two weeks, gave no odor. On being shaken, the sludge settled to the bottom in about ten minutes, leaving a perfectly clear liquor above it.

No particular effort was made to determine either the amount of iron and copper added to the sewage or the cost of operation. The weight of the plates was 2059½ lb. at the commencement of the experiments, and 2051 at the end. In all, some 276,000 U. S. gal. of sewage were treated in about 52 hours. A log-sheet of one of the experiments (Dec. 4, 1913) is shown at the top of this column.

The experiments were performed under the direction of W. R. Worthington, engineer of the sewer section, acting on instructions from R. C. Harris, commissioner of works, and were under the immediate direction of the writer.



EXPERIMENTAL PLANT FOR ELECTROLYTIC TREATMENT OF SEWAGE AT TORONTO, ONT.

Fig. 1. Motor generator and water rheostat. Fig. 2. Detail view of portion of plates and weiv. Fig. 3. View of flume, pump and wire connection.

Sidewalk Tile at Jacksonville, Fla., are being made from brick screenings from old paving brick run through a stone-crusher—the crushed brick being used for concrete. The tile are 18-in. hexagons, 1½ in. thick, of 1:3:5 mix, and are top-faced with granite screenings. These screenings come from old granite curbs, crushed for concrete. The tile cost 5c. each, including labor, cement and sand.

Unusual Method of Laying an 8-In. Wrought-Iron Submarine Pipe Line

By T. H. Vaughan*

The opening up of the new petroleum fields along the Gulf coast of Mexico during the last few years involved difficult problems in shipping the oil after it was piped down to the coast; for at present, the only ports on the Gulf coast of Mexico in which ships of any size can enter are Tampico, at the mouth of the Pánuco River, Vera Cruz, and Puerto Mexico, at the mouth of the Coatzacoalcos River.

Lack of Suitable Ports—All three of these ports necessitated extensive and expensive work before they could be made to meet modern requirements. The first and last are river ports, and had shallow and dangerous bars at the mouths of the rivers. Both were opened by running training walls out beyond the bars, and allowing the rivers, aided by dredging, to scour a deeper channel.

At present no oil is exported through Vera Cruz. Fuel oil and refined oils are shipped from the Mexican Eagle

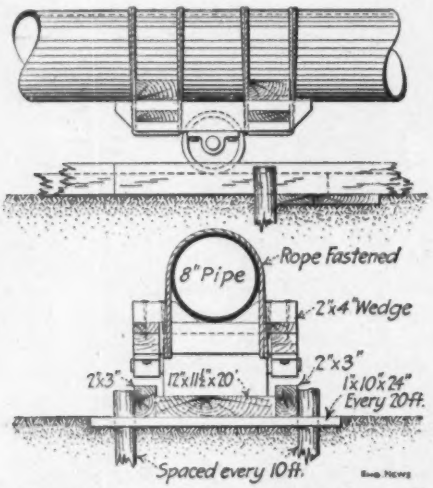


Fig. 1. Details of Track and Dollies for Launching a Submarine Pipe Line

Oil Co.'s refinery at Minatitlan (on the Coatzacoalcos River) through Puerto Mexico, but Tampico, with from 21 to 22 ft. over the bar, is the chief exporting port for crude oil. Tampico bids fair to be eclipsed by Tuxpam, the only other point on the coast from which oil is shipped at present.

On account of the bar at the mouth of the Tuxpam River, all freight has to be lightered across from ships anchored in the open roadstead, or lying in the shelter of Tuxpam reef. When, however, the Mexican Eagle Oil Co., Ltd., developed its phenomenal "gusher" at Potrero del Llano, it was decided to use Tuxpam, the nearest point on the coast, and to pump the oil aboard ship by means of submerged pipe lines carried out to deep water beyond the influence of the shore breakers.

Submarine Pipe Lines for Oil Shipment—The company had already, in the previous year, established a pumping station, and installed two 6-in. pipe lines, one of which ran out to sea 3608 ft., and the other 5150 ft. from high-water mark. These pipe lines had given satisfaction, and had proved the feasibility of this method of shipping oil, after one or two troublesome details had been overcome.

Physical Characteristics of the Tuxpam Roadstead—The Tuxpam pumping station is situated at the mouth of the Tuxpam River. There are only 4 to 6 ft. of water over the bar at the mouth of the river, so a loading station inside was out of the question. There is a reef 7 miles east-northeast off the mouth of the river, which affords good shelter for shipping; but a submarine pipe line 7 miles long and laid at a depth of 90 ft., the depth between the shore and reef, was not practicable. Therefore, the only alternative was to load vessels in the open roadstead outside, where fortunately there is good anchoring ground.

The Mexican Eagle Oil Transportation Co. has now in service tank steamers with a dead weight capacity of 15,000 tons of oil, which, when loaded, have a draft of 28 ft. It is calculated that their movement, when loaded, in a heavy sea, will be about 10 ft. more, making 38 ft. It was therefore decided to carry the pipe lines out to 43 ft. of water to give a further margin of safety.

The tidal range along the Gulf coast is about 2 ft. The prevailing winds from the beginning of November to the end of March are northerly, blowing sometimes with severity, when a "norther" sweeps across the Gulf. During the remainder of the year, the winds are from the southeast. The sea bottom along the coast slopes from high-water mark about 1 to 120. The bottom is a hard fine sand, chiefly the coral detritus common to the Gulf coast. Back from the high-water mark are sandhills blown up by the "northers," from 6 to 20 ft. high, and back of these are low swampy lands for several miles inland.

Submarine Pipe-Laying—The first two pipe lines after being hauled through the breakers were laid from barges—a slow, costly and unsatisfactory method, as the pipe was bent and twisted in laying when the deeper water was reached. It was, therefore, decided to lay the new pipe lines by connecting up the whole length to be submerged on land and hauling it out to sea by a tug in one operation.

The pipe used fulfills the following specification:

Nominal external diameter, in.	8⅝
Actual external diameter, in.	8⅝
Nominal internal diameter, in.	8
Actual internal diameter, in.	7⅞
Thickness, in.	⅜
Actual weight, lb. per ft.	32.26
Threads per in.	8
Taper per ft., in.	¾
Angle thread, deg.	60
Length of threading, in.	3
Couplings, external diameter, in.	9¼
Length of recess, in.	5⅞
Length extra long, in.	7½
Weight, lb.	30

The gently sloping beach, the low sandhills and the long low stretch of land back of the sandhills favored this method of laying the pipe. The locations for the pipe lines were established by ranges.

Launching Track—An embankment was built at an elevation of mean high tide along the course on which the pipe was to be launched. On this embankment was laid a timber track, as in Fig. 1, consisting of 2x11½-in. planks, with 2 pieces of 2x4-in. studding nailed to the sides as guides. This track was carefully tamped and leveled up, and 2x10-in. supporting pieces placed under each joint. It was further strengthened by driving

*Chief Construction Engineer, Cia Mexicana del Petroleo "El Aguila," S. A., Tampico, Mexico.

stakes about 4 ft. long and 3 in. in diameter every 10 ft. on either side and flush with the tops of the guides.

The pipe was connected up alongside the embankment, and then lifted up upon timber dollies, one being placed under every other joint of pipe, 40 ft. apart, c. to c. The pipe was then painted with "Texaco" dip, applied hot, and wrapped with burlap. The burlap was cut in strips 20 in. wide and applied after the manner of a hospital bandage. After it was on another coat of dip, also hot, was applied.

Unless the wooden trough, which was to serve as a track for the dollies, was absolutely level, the nose of

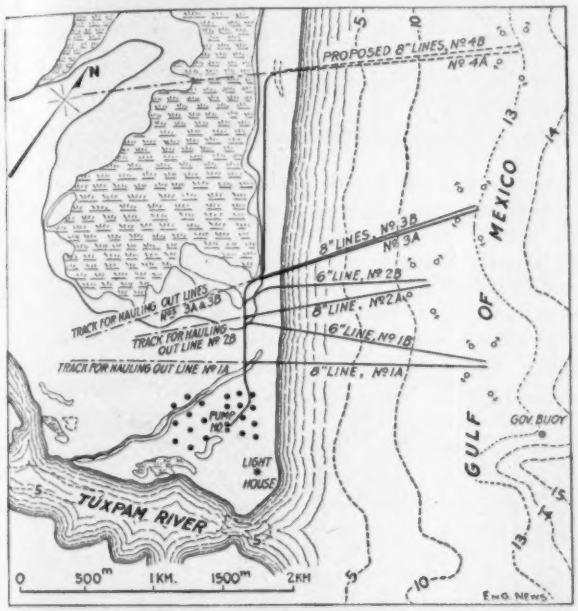


FIG. 2. MAP SHOWING LOCATIONS OF SUBMARINE OIL PIPE LINES, MEXICAN EAGLE OIL CO., LTD., TUXPAM, MEXICO

the dollies would dip and drag along the track until the weight of the pipe came upon them again; they would also become unevenly spaced along the pipe. Therefore, the dollies were lashed to the pipe with ⅜-in. rope.

A small pit was dug at the end of the timber track into which the dollies dropped when they arrived at that point. Men were stationed here to cut the ropes and lift the dollies out of the pit.

TOWING THE PIPE LINE OUT—It was thought that unless the ship hauling the pipe out was able to keep sufficient headway to hold its course, currents or winds might cause it to drift either north or south of the line, and the pipe would be hauled off the track. To prevent this, heavy guides, well braced, were sunk in the sand on either side of the line at about high-water mark. The guide posts had rollers placed vertically, so that the pipe would move evenly should the ship be unable to maintain its course in range with the pipe and track on shore. This proved a wise precaution.

A bull-plug was screwed into the end of the pipe. A 1¼-in. cable of plough steel 1750 ft. long was run ashore and made fast to the end of the pipe; the other end of the cable was buoyed out at sea.

The hauling steamer was delayed a day in arriving at Tuxpam, and thus the cable became embedded in the sand, and there was some difficulty at first in getting it free. This is where the guides on shore proved their value; the cable had been carried by the shore currents to the south, and the first pull was not in a straight line. Consequently, pipe scraped against the guides, the rollers came into play, and the pipe after stripping a few lengths of burlap moved out evenly.

One of the company's tank steamers, the "San Cristobal," of 3900 tons capacity, was used as a tug to haul the pipe. This boat took up its position on range, dropped two anchors forward, swung around, and picked up the cable. As soon as everything was made fast, winches were started hauling on the forward anchors, and the pipe moved off slowly. As soon as the anchors came home, the boat slackened off the cable, steamed out to sea, and started the same performance over again.

As soon as the anchors came home a second time, the pipe was moving out so easily that the boat steamed out to sea with the remaining pipe, moving at the rate of about four miles an hour. Signals had been arranged on shore to indicate when she should stop hauling, and the end of the pipe at sea came to rest within 50 ft. of the mooring buoy, previously placed.

The total length of pipe hauled as noted above was 5150 ft., and the whole pipe line weighed 83.096 short tons. The number of timber dollies used was 130, the weight on each one being 1277 lb. The same company has since successfully launched three additional lines by the same method.

SEA-ENDS OF PIPE LINES—After the sea-end of the pipe has been anchored, a diver is sent down to remove the plug and put on a valve and an 8-in. flange. To this flange are bolted on six lengths, each 20 ft. long, of 8-in. armored hose. As the end of the pipe is at a depth of 43 ft., it is below wave action. There is no litoral current to speak of. Therefore, there is nothing to disturb the ends of the pipe lines, and the ship's motion as well as the necessary curves are taken care of by the slack in the long length of flexible hose.

To the extreme end of the hose a small marking buoy is attached, also a chain for hoisting the hose. The hose when not in use lies on the bottom of the sea. Upon the arrival of the vessel off Tuxpam Roads, the marine superintendent goes on board, and gives instructions as to which berth the vessel is to occupy. All vessels are instructed to come equipped with a small derrick for lifting the hose, and also for taking the weight of the hose during pumping, and keeping it clear of the ship's side. The boom is so arranged as to plumb 3 ft. clear of the vessel.

As soon as the vessel is moored, the end of the hose is lifted, and flanged on to the receiving pipe on board which distributes the oil to the various tanks in the ship. The vessel hoists a "pump slow" signal, and when all is going smoothly, a "pump full speed" signal. These signals are answered from the pumphouse on shore. When the tanks are full, the vessel signals "stop pumping" and disconnects the hose; a blind flange is put on the end of the hose, and it is lowered to the bottom of the sea. The vessel then slips its moorings, picks up anchors, and sails for its destination.

Owing to chafing and perpetual movement, the armored hose at the end of the line has to be renewed frequently. If a fresh length is necessary below water level, it is put on by divers. If, however, the length to

be renewed can be placed above water level, the work is considerably facilitated.

To avoid loss of oil, a valve is placed on the line just above high-water mark, and also, as stated, at the sea end of the pipe just before the hose connection.

Lining a Timbered Tunnel with Concrete; Southern Pacific Ry.

By Geo. W. Wade*

In the original construction of the Southern Pacific Ry. lines on the Pacific coast, all tunnels were lined with timber. At various times in recent years, it has been necessary to make extensive repairs to certain tunnels, and in the course of such repair work, standard concrete portals have been built to replace the old timber portals and a concrete barrel or lining of the new standard width constructed a certain distance into the bore. This distance depends on the nature of the ground penetrated, but it has been deemed essential to build at least 30 ft. of the concrete barrel for protection against grass fires.

A method of doing such repair work, carried on always with the usual traffic conditions, is illustrated in the accompanying cuts. While the drawings and the cost statement relate to the lining of tunnel No. 11 (located on the Cuesta grade, on the Coast Division) they are indicative of the scheme generally followed for such work.

In Fig. 1, the left-hand drawing *A*, is a section of a typical old timbered tunnel (*a, b, c, d*). A standard of the railway company is that the center line of a tunnel built on a curve shall be 6 in. inside of the track center line, in order that proper clearance shall exist between the timbers and the top of a car when inclined to the elevation of the outer rail. The maximum elevation given to outer rails on this particular grade (which is 2.20%) is 3½ in.

The upper part of section *A* shows the first step of the improvement work, which consisted in driving a heading or drift (*b, e, f, c*) above the roof of the tunnel, the original packing being removed along with the necessary additional excavation. The material was excavated from the corners and the side walls trimmed as fast as the new timber section was advanced. It was usual to maintain the drift about 20 ft. in advance of the timbering.

Section *B* (Fig. 1) shows the approximate earth line and the new three-segment timbering in place, the old timbers being removed. The position of the old timbers is indicated by the dotted line.

Square sets were used in bad ground where greater pressures seemed to demand stronger supports. Section *C* shows the square-set section in position, the status of the work being the same as in section *B*. The cost of erecting the square sets was greater because of the additional labor involved in raising the long heavy cap and the double plumb-post; this latter member consisted of two 8x17-in. timbers. In placing the cap, it was necessary to keep the two half-posts spread until the cap was lowered into the dapping, some manipulation usually being necessary in inserting the bolt holding the cap and two half-posts together.

After having set the timbers and allowed a reasonable time to elapse for natural settlement, the concrete forms and reinforcing rods were put in place, as indicated in section *D*. At this stage of the work, it was necessary to have the track thrown temporarily to the tunnel center and the elevation of the outer rail taken out in order to give sufficient clearance between cars and forms. The arch of the form was set to exact position by means of wedges placed between the base of the arch rib and the top of the form posts.

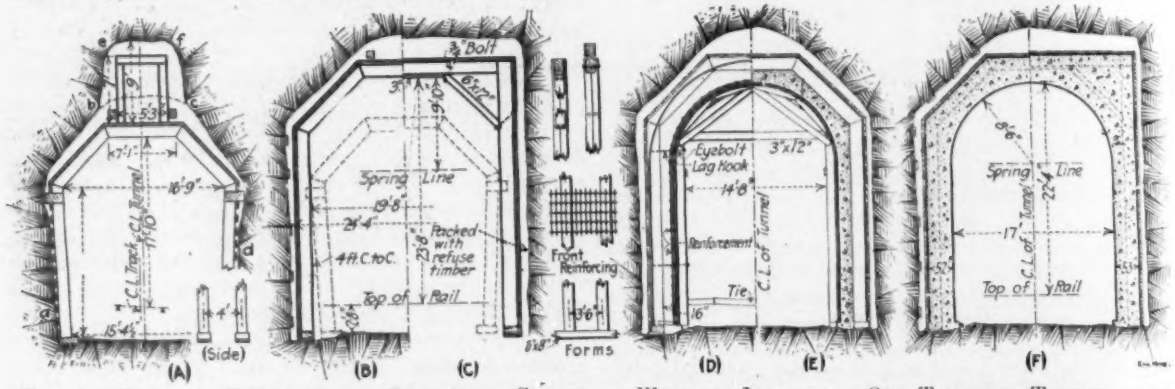


Fig. 1. Sections Showing the Successive Stages of Work in Lining an Old Timbered Tunnel with Concrete; Southern Pacific Ry.

A. Original section and new top heading for enlargement. B. Half section with new three-segment timbering. C. Half section with new square-set timbering. D. Half section with forms in place. E. Half section with side wall and arch concreted. F. Completed tunnel section with concrete lining in three-segment and square-set timbering.

Section *E* shows the concrete in place between and around the timbers. There was no concrete placed back of the timbers, however, the space being filled with lagging and tightly packed with refuse timber. Section *F* shows the concrete lining in place and stripped of the forms. The left half shows typical three-segment timbered section concreted, and the right half shows the square-set design. After the forms had been removed, the surface of the concrete was given a cement wash.

This particular job was carried on without delay to traffic, with an average of from 14 to 20 trains in 24 hr. Inverts were not considered necessary, the formation consisting of various conditions of shale, with here and there a dike of serpentine and diabase. In wet places, the usual weeping holes were left in the concrete wall.

To remove the excavated material, small dump cars were used on a narrow-gage track laid between the main

*Herald Hotel, San Francisco, Calif.

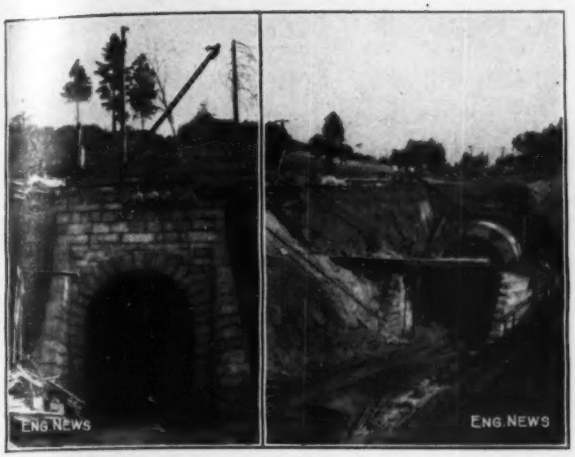


FIG. 2. MASONRY LINING AND PORTAL FOR TUNNEL

(The left-hand view shows the masonry portal, and hte right-hand view shows the concrete and lining beyond the portal.)

TABLE I. COST OF CONCRETE LINING FOR TUNNEL NO. 11; NEAR SAN LUIS OBISPO, CAL.; SOUTHERN PACIFIC RY. (COAST DIVISION)

Material	Three-segment timbering Quantities per lin.ft.	Three-segment timbering Cost per lin.ft.	Square-set timbering Quantities per lin.ft.	Square-set timbering Cost per lin.ft.
Lumber	1092 ft. b.m.	$28.76	1253 ft. b.m.	$34.96
Hardware	42 lb.	1.02	48 lb.	1.18
Reinforcing rods, ¾" twisted iron	750 lb.	16.16	750 lb.	16.16
Cement	6.8 bbl.	13.08	9 bbl.	15.90
Gravel	8.8 yd.	2.63	10.5 yd.	3.16
Rock	1.9 yd.	1.15	2.3 yd.	1.37
Lights, candles, carbide, etc.		2.15		2.12
Miscellaneous		8.23		9.85
Percentages		2.74		3.36
		$75.93		$88.06
Labor				
Mining	9.5 yd.	37.20	11.5 yd.	44.90
Framing and resetting timbers		6.80		9.59
Setting concrete forms		4.87		4.79
Bending and placing reinforcing rods		2.57		2.53
Mixing and placing concrete		18.44	7 yd.	21.73
Removing forms		2.18		2.14
Handling material		7.18		8.63
Moving outfits and cleaning up		5.12		5.19
Miscellaneous		5.66		7.98
		$90.02		$107.48
Summary				
Material		$75.93		$88.06
Labor		90.02		107.48
Total		$165.95		$195.54

TABLE II. COST OF RENEWING OLD WOODEN PORTAL WITH STANDARD CONCRETE PORTAL AT TUNNEL NO. 11, NEAR SAN LUIS OBISPO, CAL.; SOUTHERN PACIFIC RY. (COAST DIVISION)

Material	West Portal 245 cu.yd. Cost per cu.yd.	West Portal 245 cu.yd. Total	East Portal 235 cu.yd. Cost per cu.yd.	East Portal 235 cu.yd. Total
Lumber, 14,100 ft. b.m.	$1.53	$374.93	$1.38	$333.15
Hardware, 498 lb.	0.05	12.25	0.05	10.77
Cement, 293 lb.	2.30	563.73	2.22	519.48
Gravel, 379 yd.	0.46	113.70	0.46	108.90
Rock, 82 yd.	0.20	49.20	0.20	46.80
Miscellaneous	1.45	355.91	1.46	338.43
Percentages	0.45	110.18	0.48	113.12
	$6.44	$1579.90	$6.25	$1470.65
Labor				
Excavation, inc. removal old portal	$0.82	$200.00	$1.28	$300.00
Setting forms	0.84	205.25	0.86	203.25
Removing forms	0.42	102.75	0.44	102.75
Building and removing staging	0.22	57.00	0.20	57.00
Mixing and placing concrete	2.56	626.64	2.42	563.10
Filling in behind walls	0.51	123.88	0.53	123.87
Handling material	1.26	309.67	1.26	296.40
Moving outfits and cleaning up	0.90	220.21	0.90	210.78
Miscellaneous	0.99	241.67	1.00	233.34
	$8.52	$2087.07	$8.89	$2090.49
Summary				
Material	$6.44	$1579.90	$6.25	$1470.65
Labor	8.52	2087.07	8.87	2090.49
Total	$14.96	$3666.97	$15.12	$3561.14

line rails. The concrete was hauled in buggies over a plank runway built between the rails to the point where it was to be used, and elevated to the top of forms by means of a cable operating on sheaves, the power being furnished by the same donkey engine supplying power to the concrete mixer stationed at the portal.

To protect the work, a reliable flagging system was organized in which telephones played an important part, flagmen's shanties being located at each end of the tunnel in places affording the best view of the automatic block signals. It was found necessary to appoint one man whose duty it became to personally notify each member of the crew working on the inside of an approaching train, as the men often became so interested in their work as to disregard the general warning. The fact that the tunnel was located on a 2.20% grade (compensated for a 10° curve) made it necessary to leave the tunnel when an up-bound train (with helper engines) passed through, the smoke and gas being too intense. Ordinarily, about five minutes time was lost waiting for the tunnel to clear itself of smoke after the passing of a train.

The accompanying tables give itemized statements of cost per lineal foot of tunnel. The completed portal and

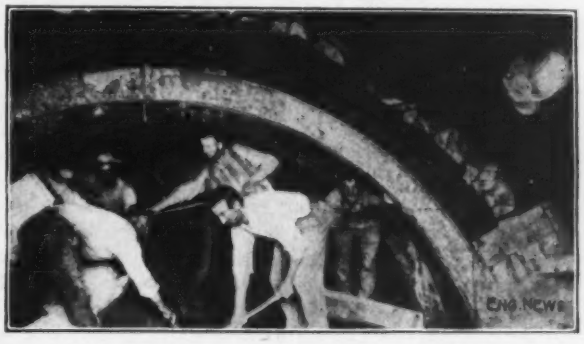


FIG. 3. PLACING THE CONCRETE FOR THE ROOF LINING OF A TUNNEL

the work on the concrete lining are shown in Fig. 2, while Fig. 3 shows the work of placing the concrete in the roof of the tunnel. These views are typical, but represent a tunnel on the Rocklin-Colfax revision of the line. Fig. 3 shows the iron arch ribs of the forms, the concrete arch upon the forms, and the packing of stone spalls above the arch.

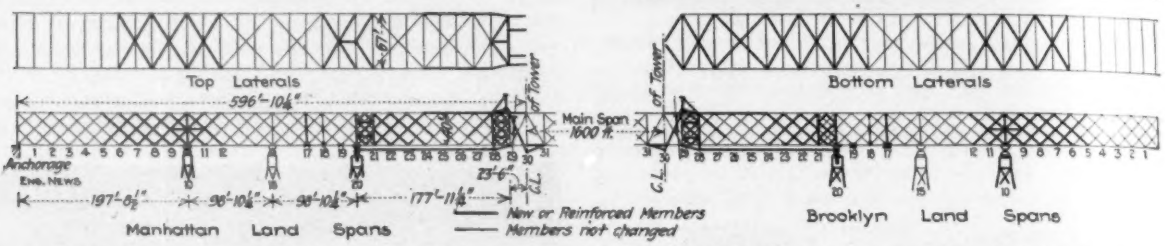
Centralization of Electricity Supply for London, England, has been recommended in a recent report to a special committee of the London County Council by C. H. Merz and W. McLellan, Consulting Engineers. They point out that the present position of the supply services is unsatisfactory as the result of a Parliamentary policy of encouraging the formation of numerous small competitive undertakings. After studying the amount and variety of the future demands of the whole metropolitan area, these engineers estimate the output needed in the near future at twenty times the present. They do not consider the enlargement of any of the existing stations in this district economical or desirable.

They recommend instead a concentration of a number of large generating stations on neighboring sites, 10 or 12 miles down the Thames. This would be under a new organization amalgamating all the old undertakings. Power would be distributed over the existing networks where possible and elsewhere supplemented by a new three-phase network; there would also be standardized a high-voltage three-phase 50-cycle primary-distribution system. The immediate outlay required is estimated at some $35,000,000. The annual saving over the development of existing plant is estimated at $850,000.

Reinforcing the Williamsburg Bridge under Traffic

The sensational performance of taking out a 10-in. bridge pin and putting a 13-in. pin in its place, done on the Williamsburg Bridge at New York City, as briefly noted in our issue of Apr. 16, 1914, p. 867, is only an item of an extensive reinforcement operation now in progress.

The Williamsburg Bridge was not designed for rail loadings as heavy as those produced by subway trains of the kind now operated. As the bridge is to be used in future as one of the most important Manhattan-Brooklyn links of rail traffic, strengthening the bridge to make it adequate for these loadings was imperative. In some instances, due to vagaries of the original design, the changes required are relatively extensive.



LAND SPANS OF WILLIAMSBURG BRIDGE, EAST RIVER, SHOWING REINFORCEMENT BEING PLACED TO ACCOMODATE EXTRA LOADING

In the land spans, the detailed study of the bridge under future heavy loading revealed two main features: (1) strength of the trusses would be inadequate, and (2) certain critical details showed special deficiency; one of these is the pin which has just been replaced. A closely related part of the bridge, the rocker which supports the stiffening truss of the main span at the tower, was replaced and additional supports were built into the towers six years ago.

One of the most complex and difficult items of the entire undertaking was the work in the panel adjacent to the main tower, including the pin replacement at 29 (see accompanying figure). The problem here was to strengthen the overhang of the stiffening truss and to strengthen the pin at its end, and to support the land span while taking out the old pin and putting in a new one. The old 10-in. pin at panel-point 29 would under the greater loading be subjected to a bearing pressure of possibly twice the limit usually set in good practice.

The procedure was as follows: A second overhang-triangle was built in panel 29-30, with diagonal struts footing on the rocker-pin in the main tower, tied back to the top chord of the stiffening truss. This "upper" triangle, together with a few corresponding items of reinforcement at the tower and in the main span panel next to the tower, provided a means for carrying the load of the land span. A girder spanning across the top of the upper triangle furnished a seat for pairs of screw-operated wedges engaging the top chord of the land span. By this means, the reaction of the land span could be transferred to the upper triangle and thus the lower pin and the original overhang triangle completely relieved of load, giving opportunity for replacing the lower-chord pin.

The relative deflection of land-span and stiffening truss is concentrated at joint 29 and the connection in the lower chord must in any event be strong enough to take considerable live-load forces.

The work of placing the new pin involved removing the old pin, boring out the pin-hole from 10 to 13 in., and inserting the new pin, at the same time attaching to the new pin the added new wind chord. The operation was extremely delicate not only because of the necessity of reopening the bridge to traffic after as short a stoppage as possible, but also because so long as the pin was out there was only a temporary wind-chord connection between the main span and the land span, and the structure was thus in some temporary instability with reference to strong lateral forces. Therefore, the entire process of pin replacement was planned out with scrupulous care and with provision for all possible contingencies.

A special drilling or boring machine, designed by the Department of Bridges and the contractor, was built by the Fawcus Machine Co., Pittsburgh. This machine was attached to the bottom chord with its cutting arbor in the line of the pin. The arbor carries a cutter-head with seven inserted high-speed steel-boring cutters; the arbor is driven by chain from a 35-hp. motor. After building the machine a dummy chord exactly like the chord to be bored in the bridge was built and the machine tested on it in the builders' shop. The aggregate thickness of metal which the boring bar had to go through was about 24 in. and the total volume of steel removed nearly a cubic foot. It took something over an hour to make the cut (from 10- to 13-in. hole) and everything went smoothly.

When it came to the actual bridge, the first difficulty encountered was that the old pin could not be pushed out even after the wedge load-transferring apparatus had relieved the pin of all its load (as determined by extensometer measurements on the members of the cantilever). It was necessary to cut the pin in two lengthwise by drilling four 2-in. holes through it and broaching out the intervening webs. This was done in day time the day before the pin replacement was undertaken, and in the meantime the two halves of the pin were kept apart by wedges.

In the night of Saturday, Apr. 11, to Sunday, Apr. 12, traffic over the bridge was stopped at 1 a.m., provision having been made for stoppage until 7:30 Sunday morning. The old pin was then collapsed by drawing out the wedges and forcing the two halves out of their firm seating in the chord, where they were rusted tight. Previously, the several members meeting at the joint had been fixed in relative position by temporary gusset-plate connections, and by pairs of 3-in. tie-rods at top and bottom chords and by spacer wedges in the bottom chord. The boring machine, set for a $13^{3}/_{64}$-in. hole, started work as soon as the old pin was out. It got through with-

out trouble, in about the same time as at the shop trial. On examining the hole, however, it was found that the bore was somewhat rough; and in the cutter-head the second cutter was found broken. Therefore, the finishing cutter was set for a second cut about 0.01 in. deep, and the completion of this cut resulted in a true and smooth hole. The 13-in. pin was then driven into place without difficulty. Two of the three webs of the new wind chord were put in place in the joint as the pin was inserted, leaving one of the outer webs to be slipped over the projecting end of the pin later.

At 5:50 a.m., the first train was admitted to the bridge and traffic resumed.

The pin in question was that in the downstream truss of the Manhattan end. The operation will have to be repeated three times for the upstream Manhattan and the two Brooklyn pins. No difficulty or delay is expected.

The work on the land span, including the construction of the new tower, was done by Snare & Triest, of New York, under contract. The control of this work by the Department of Bridges includes a most carefully prepared series of working schedules in which each individual step is closely specified and every caution as to the proper sequence of steps or proper safety provision to make at each step noted in the schedule for the respective part of the work.

The work is under the direction of the Department of Bridges, F. J. H. Kracke, Commissioner, Alexander Johnson, Chief Engineer, A. L. Bowman, Consulting Engineer, L. S. Moisseiff, Engineer of Design and J. R. Geaghan, Assistant Engineer in charge in field.

An Investigation of the Use and Rating of the Current Meter*

By Chas. P. Rumpf*

Since 1851, when the first American patents were taken out for current meters, more than fifty devices for velocity-measuring instruments of this kind have been patented. Of these, the most common now in use are the Fteley and Stearns meter, the Haskell, the Price and the Ellis. The distinguishing difference in these is that the first two have vanes revolving about a horizontal axis and have a screw-like action, while the last two have cups revolving about an axis that is vertical.

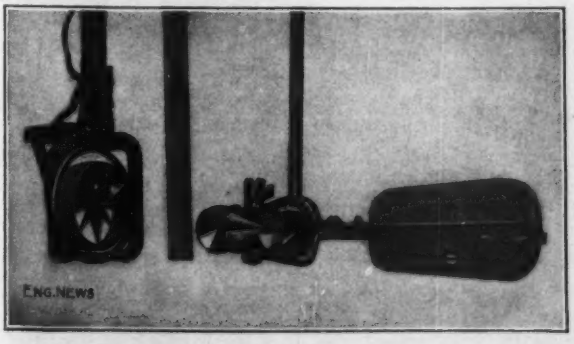


Fig. 1. View of Current Meters Used in the Test

(Fteley and Stearns or screw type on the left. Price or cup type on the right.)

During 1912, in the rating tank of the Hydraulic Laboratory of the Rensselaer Polytechnic Institute, under the direction of Prof. Lewis F. Moody, the writer made an exhaustive set of experiments involving more than 1100 runs to determine the relative merits of the horizontal axis and vertical axis meters when they were subjected to various influences.

The tank used for rating the meters is 90 ft. long, 3 ft. 8 in. wide, and has a water depth of 3 ft. 6 in. The car from which the meters were suspended was hand propelled and furnished with a tachometer fastened to one of its wheels so that the speed could be observed and a constant speed maintained. The recording device consisted of a chronograph with three pens electrically operated, by means of which the feet traversed, the corresponding seconds of time, and the revolutions of the meter were obtained. The functions feet per second and revolutions per second were therefore ascertained with the highest degree of accuracy.

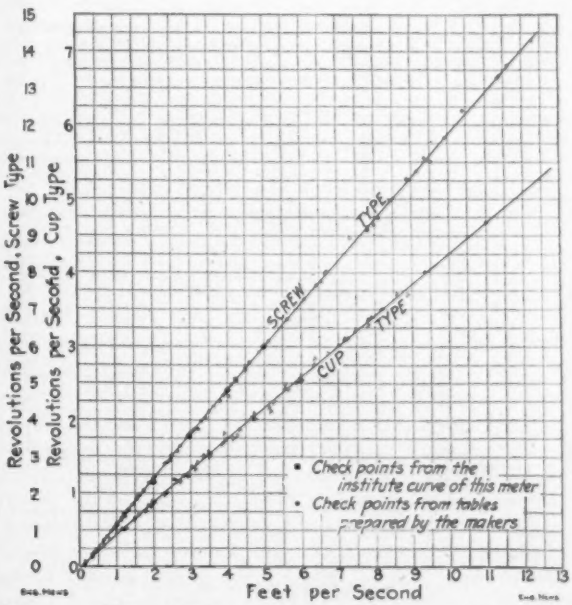

Revolutions per Second, Screw Type
Revolutions per Second, Cup Type
Feet per Second
SCREW TYPE
CUP TYPE
• Check points from the institute curve of this meter
• Check points from tables prepared by the makers

Fig. 2. Rating Curves of the Screw and Cup Types of Current Meters

The Fteley and Stearns model meter, chosen as typical of the screw-type or horizontal-axis meter, was a Buff and Berger instrument No. 704, having a 3⅝-in. diameter wheel, and is shown on the left in Fig. 1. The Price model meter, typical of the cup-type or vertical axis meter, was a No. 23 Gurley & Co. instrument, with a cup circle diameter of about 4 in., and is shown on the right in the same view. The Buff and Berger meter is made to be used with a rod only, the Gurley meter with either a rod or a cable. The former is fitted so the revolutions may be recorded either electrically or mechanically; the latter is made to record revolutions acoustically or electrically through a special waterproof head. Roughly, the Fteley and Stearns meter makes one revolution per foot of distance traveled, and the Price meter one-half revolution.

A comparative rating curve of the two meters is shown in Fig. 2. Both meters give practically a straight line,

*Condensed from the Macdonald Prize Thesis of 1912, Rensselaer Polytechnic Institute.

†144 Ross St., Brooklyn, N. Y.

but the results of the Fteley and Stearns meter are slightly more consistent than those of the Price.

It is a recognized fact that cross-currents in a stream introduce errors in current-meter readings. To determine what the effects of such currents might be, a thorough series of ratings was made with each meter turned at various angles with the longitudinal axis of the tank. Fig. 3 gives the curves obtained when the Fteley and Stearns meter was turned by increments of 10 degrees from 0 to 90 degrees, and Fig. 4 curves for the Price meter similarly treated. The revolutions of the former may be seen to decrease almost proportionally to the number of degrees turned. The latter, the Price, when turned with its head to the left, had its revolutions increased but when turned to the right had them decreased, a peculiarity doubtless due to the interference of stream lines through the yoke of the meter.

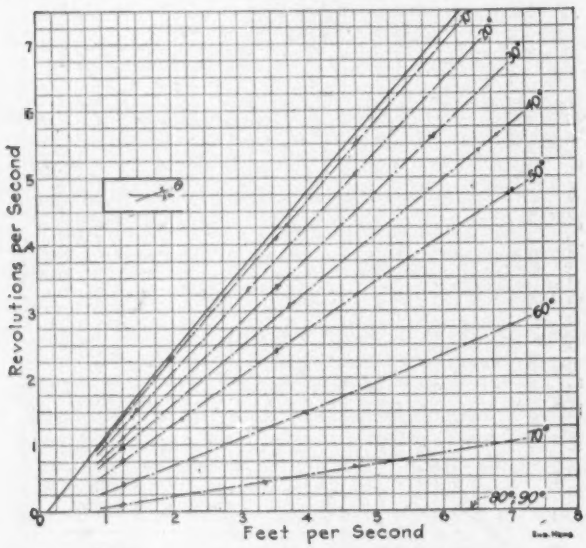


FIG. 3. RESULTS WITH SCREW TYPE

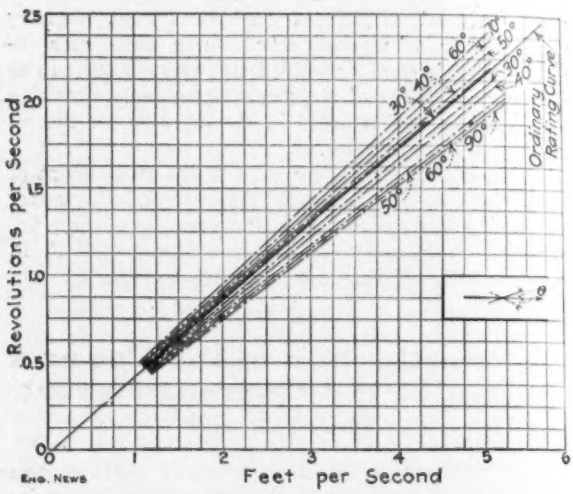


FIG. 4. RESULTS WITH CUP TYPE

FIGS. 3 AND 4. CURVES SHOWING THE EFFECT OF TURNING CURRENT METERS AT VARIOUS ANGLES

(In Fig. 3 the meter was turned to the left or to the right with the same result at corresponding angles. In Fig. 4 the lines above the rating curve were obtained by turning the head of the meter to the left and those below the rating curve by turning it toward the right.)

In order to observe what effect rating or using meters at different depths would have, a series of tests was made, in which the meters were placed in all vertical positions from having their vanes only partly immersed to being as near the bottom of the tank as possible to put them. It was found that both meters would follow their regular rating curves in all ordinary depths, but that when brought nearer the surface than 1 ft., measuring from the center of wheel, the revolutions of both meters were decreased, and when brought nearer the bottom than 6 in., the revolutions of the Price, or cup, meter were decreased and the revolutions of the Fteley, or screw, meter increased.

Rating curves were made to determine the effect of using meters too near the sides of the channel. The screw-type meter gave a greater number of revolutions than usual when placed as near the side of the tank as possible. It was found with the cup meter that if the open part of the cups was near the side of the tank as the meter advanced the revolutions were increased, but if the point of the cups was near the side as the car advanced the revolutions decreased.

To determine what effect the side swaying of a rating car would have on the rating curve of meters, a special frame was constructed by which an oscillating motion could be given to the meters. This frame was worked somewhat like a sliding valve. An iron flywheel, turned at the rate of about a turn per second, worked an iron rod fastened eccentrically to the wheel on one end and to the frame on the other end. The meter was fastened to the frame and both were given a side-to-side motion as the car advanced. The cup meter is so constructed that it records positively, no matter whence the current, and its revolutions are evidently increased by this motion. The oscillating motion was found to decrease the revolutions of the screw-type meter.

Miscellaneous tests were made with the following results. Rating the screw meter backwards decreased its revolutions. When the meters are only partially covered, as in very shallow water, the curves are very eccentric and the curve below the regular rating curve. Curves for the cup meter are the same whether the tail is attached or not. Runs were made with the cup meter suspended by a cable, having a 10-lb. torpedo weight hung on and the tail attached. Up to velocities of about 3 ft. per sec., the curve given is almost the same as the regular rating curve, but for higher velocities the revolutions are increased. This is probably due to the fact that the component of velocity that keeps the meter back and raises it up also turns the cups faster. The cup meter was tilted up and down on successive runs when held by a rod. Curves from the data obtained show the revolutions to be decreased, and that the decrease is the same for corresponding angles whether the meter be tilted up or down. To simulate the turbulent conditions often found in channels, tests were made with the water stirred up in the path of the meters. Although turbidity seemed to tend to decrease the number of revolutions, the points obtained were too irregular to give a satisfactory curve.

Editorials

The Absurdities of Engineering Competitions

The absurdities resulting from bridge competitions, particularly when they are conducted by the average city council, come to light every time a competition is held. The latest which has been brought to our notice is in a small city in the South. There were five entrants in the competition, which was for a concrete bridge to cost about $75,000, but the council narrowed them down to two because the other three designs were ribbed arches, and, according to the council, public sentiment was against holes in a bridge!

This council was made up as follows: One locomotive engineer, one street-car conductor, one drummer, one dentist, one insurance man, one ice-cream manufacturer, one grocer, one drygoods man, and one lumber dealer. Obviously, they were quite competent to decide upon a bridge design. With unexpected modesty, however, they have called in, "to decide upon the respective strengths of the two designs," a building inspector from an adjacent large city.

It is not strange that such results as this are common when laymen legislators or administrators meddle with engineering matters. Nor are they particularly to blame. There are times when ignorance is a valid excuse. It does seem strange, however, that our engineering societies do not make an effort to establish some standardized practice in such matters, so that at least the excuse of ignorance may be removed.

Guarding against Expansion in Wood-Block Paving

In the laying of wood-block paving, there is perhaps nothing which gives the engineer more concern than the chance that the paving may some day "blow up." It is easily possible by proper specifications and inspection to secure good material and to have it well laid. The trouble from "bleeding," which frequently occurs, can be taken care of by covering the pavement with sand or other absorbents. Systematic application of grit to the pavement in slippery weather will remove the objections of teamsters. It is rather puzzling to an engineer, however, to know what to do to prevent the rising of mounds in the street looking like an incipient volcano, the result of some long-continued soaking rain by which the blocks have become thoroughly saturated.

On a large wood-paving contract in the vicinity of New York City, a fierce local controversy has arisen and the specifications under which the work is being carried out have been bitterly attacked by those who are endeavoring to stop the work. One of the points which has been raised by these critics is a clause inserted in the specification by the engineer for the direct purpose of preventing the blowing up of the pavement in wet weather, especially on parts of the street which are of exceptional width. The clause referred to reads as follows:

> The blocks shall be thoroughly wet by immersion in suitable tubs or tanks of water, just before being laid, care being taken to prevent the water becoming a nuisance or doing any damage to the work.

The critics claim that the extra labor in handling involved in this requirement will add some $4000 to the cost of handling the 4,000,000 blocks and over required for this work. We quote from one of these critics as follows:

> I have never known newly creosoted blocks to be dipped in water before laying, although I have heard of blocks which have been held back from being laid for a long time, and exposed to the weather, being thus dipped. I have, however, laid creosoted blocks which have been exposed for two years without wetting them and had no trouble with the pavement expanding. To dip fresh oil-treated blocks in water would be useless.

It would seem to us very doubtful whether freshly creosoted blocks would absorb enough water by dipping before laying, to be worth the trouble and expense of attempting it.

It would be exceedingly interesting, we believe, if the Bureau of Standards would make some such tests upon the stresses in wood paving due to expansion as they have made on concrete paving. There is considerable evidence to indicate that a blowup from expansion is most apt to occur when rain follows a long period of extremely dry and hot weather, during which the blocks become thoroughly dried out and sand and dirt fill the joints, so that when the pavement is again expanded by moisture, the slack has been taken up, so to speak. If this is a correct diagnosis, it would seem that systematic sprinkling of wood-paved streets during dry weather might be an important safeguard in preventing trouble when the drought is broken.

Tunnel Lining and Tunnel Fires

While the use of concrete or brick lining for tunnels is common on Eastern railways, in the West a very large majority of railway tunnels are lined with timber. As time goes on and the timbering begins to reach the limit of its life, the matter of putting in a new and permanent lining comes up frequently as a problem for the engineer. While a permanent lining (rather than a renewal of the timbering) will be warranted in most cases it is well to note that the cost would often have been prohibitory at the time of the original construction of the tunnel. Recent work in building concrete lining on the Southern Pacific Ry. is described elsewhere in this issue.

An objection to timber lining is the danger of the timbering catching fire, thus blocking traffic and often causing extensive caving of the tunnel. Such a case was described in our issue of Jan. 1, 1914, the fire being started by burning brush at the tunnel entrance. The tunnel lin-

ing fires set by locomotive sparks appear to be surprisingly infrequent.

The danger is minimized also when oil fuel is used, as the engines then throw very few sparks. We are informed that on the coast lines of the Southern Pacific System where oil fuel is used exclusively, there has been very little trouble from tunnel fires, and that in no case has such a fire been traced directly to engine sparks. The chief danger is from outside grass or brush fires spreading to the tunnel, as in the case noted above. To provide against this, it is the practice to keep grass and scrub removed within a distance of 100 ft. from the portal, while each portal is equipped with water barrels and buckets and a ladder, and in dry season extra patrolling of the line is done.

Our record of tunnel fires is limited, but we note the following. In 1909, tunnel No. 9 on the Shasta Division of the Southern Pacific (near Marysville, Calif.) was set on fire presumably by a fusee thrown out carelessly by a trainman. The fire was extinguished before much damage was done to the timbering, but the tunnel could not be used at once on account of the caving in of the portal. It was possible to lay an outside track around the tunnel and traffic was not materially interfered with. The Atchison, Topeka & Santa Fé Ry. was obstructed in 1908 by the burning of the Franklin Tunnel in Contra Costa county, Calif. Conditions were such that traffic was detoured and the tunnel was left to burn itself out; it was out of commission for about six months. A portion of the timber in the Big Horn Tunnel, a few miles south of Billings, Mont., on the Yellowstone Division of the Northern Pacific R.R., burned about 1900. In this case, also, traffic was passed around the mountain.

The fire danger is much greater in snowsheds than in tunnels because openings are more numerous, so that there is liability of free air currents to fan any sparks into a blaze.

Referring again to the Southern Pacific Ry., we are informed that practically all the tunnels on the system are lined with timber, with the exception of five tunnels with brick and concrete lining on the Bay Shore cutoff, south of San Francisco, which was built in 1907-08. In recently built tunnels, however, the practice is to use a masonry portal and concrete lining for a distance of 50 to 200 ft., partly to support the looser material near the entrance and partly to eliminate the danger from outside fires. Where extensive repairs are required at the older tunnels, it is the policy to replace the timber portals by masonry and to put in a certain length of concrete lining at each end, in the same way as at new tunnels.

Railway Freight Rates and Prosperity

In the opinion of those best competent to judge, the question whether the latter half of 1914 is to witness a revival in business activity depends more than anything else on the question whether the railways are to have their prayer granted for an increase of 5% in their average rate of freight charge.

From one point of view, this may seem absurd. What difference does it make to the rest of the business community whether the money which this increase in freight rates would involve, remains in the hands of the shippers or goes into the railway treasury? Here, for example, is a cement manufacturer. The freight charge on cement is a large proportion of its final cost to the user. If 5% is added to the freight charge on all cement shipments, then either the cement manufacturer must make that much less profit on his year's business, or the dealer in or user of cement will have to pay a higher price for it. Whichever party gets the money, it will be spent anyway.

It is not merely then, because it will cause more money to be spent in the community, that this advance of 5% on railway freight charges will bring about business prosperity. The explanation for the claim that increased freight rates will bring about a revival of business must be sought rather in the moral effect of such an advance.

Every business man understands that the existence of a bankrupt concern or a concern dangerously near bankruptcy in a community involves risk of loss to all the other concerns doing business with it, and eventually the chain extends throughout the whole community. There is abundance of proof that the railways as a whole, while not by any means on the verge of bankruptcy, are working with so small a margin of profit that their financial condition is a menace to the whole business world.

The reasons for this condition have been many times set forth and ought to be well understood by every intelligent man. Briefly summarized, the railways have year after year been compelled by the State and Federal authorities to sell transportation at lower prices. At the same time, the prices they have had to pay for all material and supplies have been steadily rising and the wages of railway labor have been forced up by leaps and bounds, not only by the increased cost of living and the general rise in wage scales in all industries, but under compulsion from the strong railway labor unions.

It is undoubtedly true that there have been prominent examples of the looting of railway companies' treasures by those in control; and there has also been, in the past, more or less neglect of the rights of the public and of the rights of employees. Now, however, the pendulum has swung to the opposite extreme. Railways have been compelled by legislation to increase their expenses by many million dollars for purposes which do not return to the public a benefit at all proportionate to their cost. This is indeed one of the penalties we have to pay for state control of public utilities.

It cannot too often be insisted upon that in the long run, those who travel and ship goods by rail and everyone who sells and buys the goods shipped by rail, which includes every individual in the community, must pay the entire expense of carrying on our great transportation systems. The legislator who votes to put the entire expense of grade crossing removal upon the railway companies, for example, does not realize that in the long run his constituents will have to pay this cost out of their own pockets.

The popular idea, of course, is that these increased expenses, which are loaded upon the railway treasury by state legislatures and railway commissions and labor unions will all come out of the pockets of the railway bondholders and stockholders. There are two things that stand in the way of such a result. One is the Federal constitution, which declares that private property shall not be taken for public use without just compensation; the other is the public necessity that the railways shall not become bankrupt. The railways require many

millions of fresh capital invested in their great plants to take care of the increase of traffic. This is necessary not in the interest of the railway company merely, but in the interest of every farmer and manufacturer and miner and mechanic.

The farmer is in favor of increasing the taxes on the railroads and votes for a legislator who introduces a full-crew train law; but the farmer would be a very much disappointed man if he were unable to ship to market his crop of peaches or grain or cattle because a bankrupt railway had not cars enough to carry his shipment when it was ready. But in order that the railways may have cars enough to carry the steadily increasing volume of shipments, the yard room in which to handle these cars, and freight stations sufficient to handle the freight without congestion, such as blocked the whole wheels of industry in many parts of the country in the fall of 1907—in order that the railways shall be able to pay for all these necessary things, it is absolutely essential that they shall be able to go to the investor, the savings bank, the insurance company, the man who saves a little money for his old age, and induce them to buy the stocks or bonds or notes of the railway company.

No small part of the present business depression is without doubt due to the fact that public confidence in the railways has been greatly shaken by the events of the past two years. There is no lack of money available for investment, even in these times of universal extravagance. Were the United States government to offer half a billion of its bonds in the market tomorrow at even the low rate of 3%, there can be little doubt that the entire issue would be subscribed at once. The railways of the country are in great need of additional capital to make necessary improvements and extensions for the economical handling of traffic. Railway investors, not only in this country but the world over, are watching intently to see whether this moderate increase in traffic rates will be sanctioned by the Interstate Commerce Commission. If it is granted, there is good reason to believe that the world's treasuries will be unlocked to supply the reasonable needs of American railways. Should it be refused, however, there would result a destruction of public confidence in railway investments, the disastrous effect of which is would be difficult to overestimate.

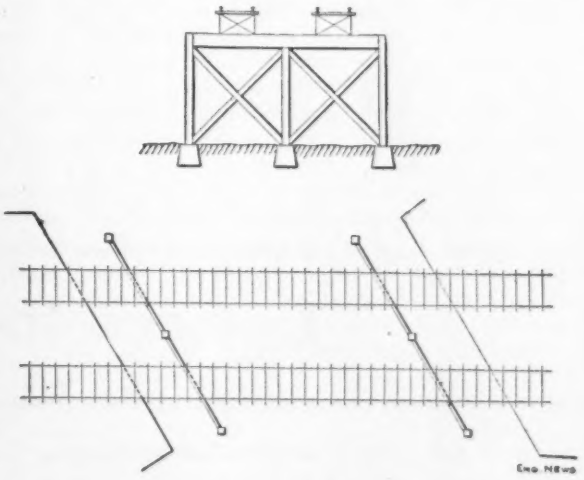
The Three-Column Bent: A Possible Source of Danger in Viaduct Construction

There is a railway bridge within a dozen miles of New York City, over which many fast passenger trains run daily, which rocks on its foundations and churns some of its footings up and down under each passing train. A member of the editorial staff of this journal stood beside this bridge a week ago and watched its movements under a heavy train. He saw the heavy steel columns on the outside of the bridge swing out sideways and sink down into the ground a finger's breadth as the weight of the locomotive came over them, and then recover slightly and plunge down anew as each truck crossed overhead.

The bridge carries a double-track railway over a street. The structure is of girders resting on six steel columns. It is "center bound"—to borrow a railway trackman's term. The two columns under the center of the bridge are always in bearing. The outside columns are only in bearing when the train weight is over them.

How long the bridge has been in this condition, we do not know and the extreme probability is that nobody knows. In fact, the discovery that the whole bridge was seesawing under trains was not made by any official of the railway, so far as we are aware. It is safe to say, however, that the bridge will not be allowed to continue to wiggle in that perilous and destructive manner under its loads any longer than necessary to bring a force on the ground and make repairs.

But a question of greater interest even than the dangers in connection with this particular structure is what caused it to get into this condition? The bridge is substantially constructed. It has been in service only a dozen years or so, during which time the loads upon it have not materially increased. Why, then, should the



footings under its side columns have settled more than those under its center columns?

It has seemed to us that the answer to this question is of much importance to bridge engineers, for the analysis we have made indicates that what has happened to this bridge is very likely to happen to any bridge of similar design. To aid in understanding the analysis, the accompanying diagram plan and elevation of the structure is printed. As there shown, the supporting bents of this viaduct are three-column braced bents. Such bents are subject to a peculiar effect not discussed in the books, and (so far as we are informed) not recognized by bridge engineers.

A three-column bent carrying a double-track superstructure is affected unequally in its several columns by the usual train loading. Only the side columns are subjected to full stress when a train crosses the bridge; the middle row of columns, being necessarily designed for double-track loading, are stressed to but one-half their capacity, except in the rare event of two trains passing over the bridge simultaneously.

So far as the steelwork is concerned, this difference of loading has no importance whatever, but the foundation may be seriously affected. If—as is current practice in bridge design—the foundation is proportioned for the maximum loads which may come on its several parts; then the earth under the outer columns of the bent will

normally be under heavier loading than that under the middle columns. Settlement (or soil compression) may be expected to be proportional to the loading, i.e., the outer columns are likely to crush down more than the middle columns.

A viaduct on rock foundations would be obviously free from this condition and the same thing would be true of certain other kinds of foundation—those which are practically unyielding. But footings on earth are virtually sure to be subject to slight compression.

Consider a traffic of fifty trains a day in each direction. The outer columns of the three-column bent are subjected each day to fifty successions of full-load impacts, while the middle column receives 100 half loadings. The rare case of full load on the middle column occurring possibly once a week may be left out of account in the comparison. Obviously, the 50 full loadings will have greater compressing or tamping action than the 100 half loadings, at least in all cases except where the unit-load on the foundation footings is especially conservative.

Thus, the conditions are clearly such as to create looseness at the outer footings, i.e., to make the bent hog-backed or rocking. Further, so soon as any slight rocking tendency begins, the outer columns will churn up and down under traffic, and the rocking condition will be rapidly intensified.

Bents of the kind under discussion are almost without exception full braced; moreover, they may have their cap girder continuous across the three columns. How such a bent will be affected by settlement of the outer columns—the danger of breaking its back, or of tearing apart, or of sudden failure under a train—may be pictured according to judgment and fancy. We need not enter into this phase of the matter: The essential fact is that the rocking or hogged condition is one of immediate danger.

Unless we have grossly overdrawn our sketch of conditions, the direct conclusion must be that three-column bents as described should never be made continuous or full-braced. Still better, three-column bents should be avoided. As a minimum requirement, the footings should be proportioned for very low unit-loading, and preferably on a basis of double-track loading for all columns. The principle is now well established in building construction, that foundations should be proportioned so as to be uniformly loaded under the average permanent load (which usually means under dead-load). The three-column bent gives occasion to apply an analogous principle.

Referring back to the little viaduct whose rocking bents we have observed, as stated at the outset, we do not profess to know certainly the cause for its dangerous condition. Pending a thorough investigation, nobody knows. We do not mean to assert, therefore, that the load-relations above sketched are necessarily the cause of its rocking, though such is our belief. But we submit the case as to the three-column bent on its intrinsic merits.

Letters to the Editor

Concrete Pole Loadings

Sir—The article, "Failure of Concrete Poles during Blizzard," in your issue of Apr. 23, 1914, p. 928, seems to the writer to be open to misconstruction, in that it might be inferred that the poles were either of improper material or design for the service in question.

It is true that the statement is made that "it may be noted that the poles in question were designed for lighter loading than they were carrying at the time of their failure," but it would have been fairer to the telephone company to emphasize the fact that the loading which caused failure was presumably three or four times the load for which the poles were designed. It is, of course, difficult, indeed impossible to accurately state the loading which occurred on any particular structure, or group of structures during the blizzard, but it would appear from the known quantities of ice and the reported wind velocities that the lines received very unusual loadings.

Personally, the writer is somewhat skeptical of the claim that the weather bureau velocities, which are ascertained on tall buildings, would actually have been found over extended areas near the ground. Further, it must be borne in mind that the loading causing failure may have been composed of severe longitudinal loads due to broken wires as well as to a large transverse loading. Since telephone wires as usually installed cannot be made safe for heavy ice and wind loads, and there will therefore, be a considerable proportion of broken wires, there is a reasonable question as to how much stress results from a high theoretical transverse loading, and how much is in reality caused by the much greater stresses from dead-ended wires.

R. D. Coombs.

30 Church St., New York City, Apr. 29, 1914.

[In order to avoid a misunderstanding of the behavior of the experimental concrete poles near Mt. Holly, it may be well to emphasize the fact that all of the poles were purposely set and loaded so as to note their resistance to combined wind and sleet. Our correspondent overemphasizes the disparity between the design and the failure loads on the poles in question. It is our understanding that the maximum loads (at the center of the cross-arm system) during the storm did not exceed 3000 lb. per sq.in., whereas the poles were designed for an ultimate of 2000 lb.

The actual loading is estimated from the behavior of the wooden poles on the same line. These were mainly of chesnut set in recent years to replace the cedar poles placed when the line was built. These chesnut poles, when new, would break at horizontal loads of from 3000 to 4000 lb. As they had suffered comparatively little decrease from their original strength and as very few of them failed, it seems safe to conclude that the poles in this section were not loaded appreciably above 3000 lb.

A number of the poles which failed were injured more or less in transportation to the line. These injured poles

were patched on the ground in order to gain information as the possibilities of making good such injuries. Very few of the repaired poles were among those which broke. This is presumably due to locations which protected them in this particular storm. Such patched poles as did break, had received only light repairs and there was no indication that the patches had a determining effect upon the point at which the pole broke.—ED.]

The Burden of Costly Passenger Terminals

Sir—I read with great interest the editorial in your issue of Apr. 23, on the "Burden of Costly Passenger Terminals." I am a daily commuter through the Chicago & Northwestern station in Chicago. This is a handsome building, but it is obvious to anyone who gives the matter a slight amount of study that many hundreds of thousands of dollars were spent on this terminal unnecessarily, and naturally the burden must fall on the people using, not only the terminal, but other parts of the Chicago & Northwestern R.R.

We will soon see the beginning in Chicago of construction of the new Union Station, to be used by the Pennsylvania lines, the C., B. & Q., the C., M. & St. P. and the Chicago & Alton. It is to be hoped that those having charge of this extensive work may be made to see the wisdom of eliminating to at least a reasonable extent, all expenditures which do not directly contribute to the utility of the station, and the comfort and convenience of the passengers. In my opinion, the traveler, whether coming or going, cares about 1% for architectural effect and similar features and 99% for utility, convenience and comfort. In some of our large stations the designers have apparently reversed these percentages.

A. F. B.

Chicago, Apr. 30.

Anchor-Bolt Tension in Steel Stacks

Sir—Referring to the article by R. Fleming in your issue of Apr. 30, on "Anchor-Bolt Tension," I should like to suggest a method of analysis that is quite simple and easily understood. Furthermore, it is a logical method of proportioning anchor bolts. It shows the stress that may be expected in an anchor bolt: the stress that would actually exist if the anchor bolts were so many steel legs each equally loaded before any wind bending moment was applied.

(1) The weight W of the stack will put a compression in each of the N legs or bolts equal to $W \div N$.

(2) The wind moment M will put a tension S in the extreme bolt to the windward side equal to

$$2M \div RN,$$

where R is the radius of the bolt circle. This tension less the above compression is the net tension on the bolt.

This gives the same result as one of the methods given by Mr. Fleming and by the Editor, namely, 51,700 lb.

The condition existing in an arc of the shell "occupied" by the anchor bolt on the windward side (the arc reaching half way to the two adjacent bolts) is the governing condition. In this arc, it is evident that there is a compression one-Nth of the weight W.

In the writer's book, "Concrete," p. 395, he derived the formula

$$S = 2M \div RN$$

This gives the tension on the shell of a circular tube in bending between two bolts or rivets, in a circle of N bolts or rivets, or the extreme stress on one of these bolts or rivets.

Exactly the same method is used by the writer to find the tension in a rod reinforcing a concrete chimney. The resultant tension on the plain concrete chimney, between two radii on the windward side, is found; then a rod is placed in this space to take that tension and relieve the concrete. Nothing could be more simple and direct and logical than this method.

The last-given equation is very useful for many cases of tubes in bending. A pipe coupling in bending, the rivets in the splice of a pipe carrying a load across a stream; these can be solved very readily by it.

EDWARD GODFREY.

Monongahela Bank Bldg., Pittsburgh, Penn.,
May 2, 1914.

Safeguarding the Client

Sir—Referring to the article in ENGINEERING NEWS, of Apr. 30, by G. G. Ommanney, entitled "Supervising the Execution of Large Contracts to Protect the Clients' Interests," I take the liberty to reply from the standpoint of "Managing the Execution of Large Contracts to Protect the Clients' Interest," which includes the system as laid down by Mr. Ommanney, with an important addition—a monthly statement (during the progress of the work) of actual costs compared with estimated costs.

As manager for a contracting corporation, doing work both on the "lump-sum" basis and the "percentage" basis, I found it necessary to employ such a system for all work. Whether the owner places an inspecting engineer on the work or not, the owner has to be satisfied of honesty and integrity in the conducting of the work. For this reason, the contractor finds it to his advantage to have an inspector on the work, or if not during the progress of the work, a general auditing at the completion by a competent engineer or architect. For this, a proper system of records and monthly statements must be kept up during the progress of the work. Besides, the manager requires an accurate monthly statement of actual costs compared with estimated costs for his own use in guarding efficiency in the different works and for obtaining unit costs for estimating labor and incidental expenses. If the manager be in a contracting company, such a statement is ready at any time to show an officer of the company or its board how the work is running.

Whether the actual cost comes up to or exceeds the estimated cost, Mr. Ommanney passes over, leaving that to a bonus or forfeiture clause in the contract. Such a contract is not a purely percentage-basis contract, but a kind of cross between a percentage-basis and lump-sum contract, and leaves a loop-hole by which the owner is exposed to advantages the contractor may take. The owner does not want at the completion of the work to fine the contractor for variation between estimate and actual cost, nor to be fined himself for "extra work." The owner should know each month exactly how the actual

costs compare with the estimated costs, that he may control the expenditure by ordering cuts or additions.

Time of completion is a feature often embodied in a clause with penalty of a fine. Because a fine without bonus is illegal, most contracts are drawn up with substitute words as "liquidated damages" in place of the illegal word "fine." Such arrangements often lead to unscrupulous dealings and do not give the owner what is intended—the completed building at a certain time. Owners do not want to contract for fines, whether called "fines" or by some equivocal term of the same meaning. Owners desire a date to count on for the completion, and want the building at that time. If the time has been calculated for an economical speed of construction, it is to the advantage of the contractor to complete by that time. The owner may find it convenient to pay an extra price to have the work pushed.

One architect claims to have solved the problem of time, by requiring an estimated schedule of procedure. Thus when the work falls behind any month, additional men, overtime or night work may be resorted to, to bring the work up to schedule, if it is advisable to pay the extra cost of such. Or, if that is not considered necessary, the owner knows each month the progress made and how much the time for completion needs to be extended.

The percentage system is no longer hypothetic; it has proven to be a most satisfactory form of construction contract and is used by some of the largest companies. Eliminating chance from the contract and employing a proper system with monthly comparisons of actual and estimated costs, the owner requires the services of a manager, experienced in estimating, purchasing, making subcontracts and administrative work. But the owner needs to pay only the manager's salary and expenses; not an insurance premium to cover risks.

FREDERICK O. LEWIS.

Garden City, N. Y., May 5, 1914.

NOTES AND QUERIES

The concreting plant described in the article "Concreting Pedestals for New Steel Plant Building," "Engineering News," May 9, 1914, p. 1023, was installed by the Pneumatic Concrete Placing Co., New York and Chicago, which is lessee and agent of the Concrete Mixing & Conveying Co. of Chicago.

Apropos of recent articles in these columns regarding offers of employment to engineers conditioned upon an investment in stocks, several correspondents call our attention to a recent advertisement for engineers by a firm in Joplin, Mo. Those answering the advertisement received a letter stating that employment was conditioned upon a subscription of $500 to the company's stock.

Annual Meeting of the National Fire Protection Association

The 18th annual meeting was held May 5 to 7 in the auditorium of the Insurance Exchange, Chicago. The address of the president, Robert D. Kohn (New York), dealt with the public aspects of the Association's work in assisting the promotion of legislation and in helping to educate architects, builders and the public as to the necessity of better standards of construction and fire-prevention. He pointed out that in too many cases some great catastrophe and loss of life is necessary to arouse the public and the legislators. The report of the Secretary, Franklin H. Wentworth (Boston) showed a total membership of 2511. The report of the Committee on Public Information noted the establishment of chapters of the Association in several cities as a very important movement, and laid stress upon the necessity of more extensive education of the people as to matters of fire-prevention and protection.

The Committee on Fire Resistant Construction pointed out that the common use of the term "fireproof" in regard to buildings often gives an erroneous feeling of security. It recommended a distinction between fire-resistant materials and methods of construction affording "full," "partial" and "temporary" protection against fire, these terms implying resistance to a severe fire for 4 hr., 2 hr., and 1 hr., respectively. It recommended also a greater consideration of the use of fire-resistant furniture and fixtures. The Committee on Safes and Vaults presented information as to fires in which vaults had either failed or had remained uninjured. It submitted specifications as to vault construction (the walls to be independent of the building walls), including the doors, lighting and interior equipment.

The Committee on Fire Protection Coverings for Window and Door Openings presented a lengthy report as to various kinds of fire-doors for different purposes. The report of the Committee on Blower Systems covered rules and standards covering blower systems for two purposes: (1) heating and ventilating; (2) conveying stock and refuse. In regard to dampers for closing blower ducts where they pass through walls, it was suggested that these two committees should confer and so harmonize their recommendations. The Committee on Manufacturing Risks submitted a report on the fire-protection of lumber yards and lumber-drying kilns, it pointed out the superiority (in point of safety) of the more recent methods of drying or seasoning lumber in moist-air kilns instead of dry kilns. No special conditions were suggested in regard to treated timber.

The report of the Committee on Safety to Life dealt particularly with means of egress from buildings (windows, doors, fire-doors, elevators, fire escapes, etc.). In regard to fire escapes, R. L. Humphrey (Philadelphia) questioned the practical value of exterior exposed fire escapes on tall buildings, and expressed a doubt whether any of those present could walk down the escapes from the 21st floor on which the meeting was held. The Committee on Railway Properties dealt with the organization of a Railway Fire Protection Association and with the consideration of the subject by the American Railway Association. The Committee on Laws and Ordinances submitted an ordinance regulating the use, storage and sale of inflammable liquids in small municipalities. The report of the Committee on State Fire Prevention Associations reviewed their important opportunities in the education of architects, builders, electricians, municipal authorities and the public in general.

The Committee on Fire Pumps submitted requirements for electrically driven pumps, to provide against interruption of service. In close relation to this was the report of the Committee on Controlling Equipments for Electric Fire Pumps. A progress report by the Committee on High Pressure Fire Service Systems led to some discussion as to the attitude of municipal health officers regarding sprinkler systems. At Fort Worth, Tex., a health officer refused to permit a sprinkler system to be

supplied with water (from an independent source) for fear that the water might in some way enter the mains of the domestic service, but he was finally convinced that the double check-valves employed provided adequate protection. Controlling valves are now being perfected for installation on high-pressure lines to protect older sprinkler systems which cannot stand the high pressure of the mains.

The report of the Committee on Standard Hose Couplings and Hydrant Fittings for Public Fire Service was read by the Secretary, and led to appreciate remarks concerning the successful conclusion of the very difficult and important work of the committee. The chairman, F. M. Griswold (New York), having presented his resignation, he was elected an Honorary Life Member in recognition of his ten years of active work on the committee in securing the general acceptance and adoption of these standards.

Among other reports were the following: hydrants and valves, gravity tanks, fire-alarm signaling systems, standards, fire hose, automatic fire apparatus, etc. A suggestion was made that a conference be held of representatives of all engineering and technical associations which have adopted standards, in order that a list of standards may be prepared.

Besides the committee reports, three addresses were made. Frank D. Chase (Chicago) discussed the adoption of the Association's standards by state and municipal action. Robert Adamson, Fire Commissioner of New York, dealt with municipal fire-prevention methods in New York; one defective feature there is the division of control among several departments. Wm. H. Merrill, manager of the Underwriters' Laboratories (Chicago), described the scope and purpose of these laboratories in testing supplies, fire-windows and doors, automatic sprinklers, fire retardants for oil and gas, etc. A branch station (exclusively for electrical testing) has been established at New York, and offices have been opened in foreign countries. The institution maintains inspectors in many factories of such materials and supplies. One afternoon was devoted to a visit to the laboratories, supplemented by a demonstration test of the Erwin chemical fire extinguisher for extinguishing fire in large tanks of oil and gasoline.

The election of officers resulted as follows: President, Robert D. Kohn, New York, N. Y.; Vice-Presidents, Charles E. Meek, New York, N. Y., and L. Wiederhold, Jr., Philadelphia, Penn.; Secretary and Treasurer, Franklin H. Wentworth, Boston, Mass.

Resolutions Regarding Fire Losses and Fire Prevention*

The destruction of life and created resources already suffered by the United States and Canada in the first four months of 1914 is deplorable evidence of the undiminished magnitude of the fire-waste problem and the need for unceasing effort for its solution.

The inadequacy of water-supplies in many cities due to their rapid growth in area and population; the more common use of explosives and inflammable oils; the growing use for manufacturing of buildings never designed for that purpose or inadequately provided with exits, and many other complex features of modern life are creating new fire hazards. These demand increased vigilance and initiative from those in authority.

The National Fire Protection Association advocates the following measures in its warfare against the needless sacrifice of human lives and property by fire:

1. The encouragement of fire-resistive building construction through the adoption of improved building codes by all states, cities and towns. The inclusion in such codes of adequate rules for exit facilities based on the occupancy for all buildings.

2. The adoption of laws or ordinances requiring the installation of automatic sprinkler systems as fire extinguishing agents in all factories, commercial establishments and city blocks. The adoption of ordinances requiring the construction of fire division walls not only as a property protecting device but as providing the best life-saving exit facility.

3. The establishment by law of a fire marshal in every state, who shall be a trained man with trained assistants competent to direct the work as statistician, educator and prosecutor.

4. The investigation of the cause of all fires by public officials.

5. The consolidation of all legal forces so as to provide for the systematic inspection of all buildings by local firemen, and technically trained building and factory inspectors, so as to insure the vigorous enforcement of rules for cleanliness, good housekeeping, and the maintenance of safe and unobstructed exits, fire-fighting apparatus and other protective devices.

6. The special safeguarding of schools, theaters, factories and all other places in which numbers of people congregate or are employed.

7. The vigorous state and municipal regulation of the transportation, storage and use of all inflammable liquids and explosives.

8. A careful study of municipal water supplies, their adequacy and reliability, with special reference to their adequacy in case of conflagrations.

9. The universal adoption and use of the safety match.

10. The education of children and the public generally in careful habits regarding the use of fire.

In the furtherance of these objects we appeal for the cooperation of all citizens. We ask them to help in the dissemination of our literature and in the use of the standards of fire protection so carefully worked out by our committies and laboratories, to the end that the lives and substance of our people shall not continue to be dissipated by a reckless, preventable waste.

*Resolutions adopted at the annual meeting of the National Fire Protection Association, at Chicago, May 5, 7.

Fire-Resistant Construction and Equipment of Buildings*

The use of the term "fireproof" is recommended to be discontinued. This general term has been erroneously applied to buildings and materials of a more or less fire-resistant or incombustible nature. Its indiscriminate use has produced much misunderstanding and has often engendered a feeling of security entirely unwarranted.

The term "fire resistant" shall be applied to all structures or materials which will satisfactorily resist the effects of a serious fire. The committee submits the following standard tests, which discriminate between fire-resistant materials and systems of construction affording "full," "partial" and "temporary" protection against fire: 1, full protection implies resistance to a severe fire for four hours; 2, partial protection implies resistance for two hours; 3, temporary protection implies a resistance to a severe fire for at least one hour.

FURNITURE AND FIXTURES

Some 35 years ago, when fire-resistant buildings of the steel-beam type were first erected, fear was expressed by some officials of the insurance companies of those days, that insurance against fire would soon be unnecessary. This feeling of security is still indulged in by many well meaning people who take it for granted that their lives and goods are safe, if within what was then called a "fire-proof" building, and what we now have more properly designated a "fire-resistant" building. In spite of some lamentable disasters, the popular imagination still is that the contents of a fire-resistant building will not burn, so that when flames are seen issuing from the windows of a building known as "fireproof" there are some people who will refer with derision to the "fireproof"

*Abstract of the report of the Committee on Fire-Resistant Construction, presented at the annual meeting of the National Fire Protection Association, at Chicago, May 5, 7.

building, and even some journals will print "fireproof but it burns."

This feeling that all depends upon the building has been reflected by those who are intrusted with the making of building laws, for though they endeavor to make building construction more and more fire resistant, they devote little or no attention to the contents. Many lives and much property have been lost due to the inflammable nature of the building's contents, and there are many instances where this loss has occurred but where little or no damage has happened to the building itself, though of the most ordinary nonfire-resistant type.

Much time and thought have been given to the planning and construction of buildings to render them fire resistant, and with good results. But with comparatively little expense greater results may be obtained by providing fire-resistant furnishings and equipments to protect the lives of the occupants and the contents of the building. There are already many buildings equipped in accordance with the standard proposed.

RECOMMENDATIONS*

1. All solid partitions to be of metal lath and cement plaster, terra cotta, brick, magnesia, or other incombustible material. All doors with trim shall be of metal or metal covered or other noninflammable material, and no wood shall be used except metal-covered.

2. All glazing of sash partitions, including doors, shall be of ¼-in. wired glass in metal frames, with the balance of the construction of metal, or metal and plaster, or other incombustible material, and no wood unless covered with metal shall be used.

3. Wooden-slat partitions or slat guards back of fire-doors or elsewhere shall not be used; wire screens set in metal frames or other metal guards are suggested.

4. All shelving shall be of metal or other suitable incombustible material. Where the contents of the shelving is of an inflammable nature, the fronts of all shelving to be provided with doors of same material as shelves. If required to be glazed, the same must be done with wired glass fastened with metal independent of putty.

5. All clothes lockers or closets shall be of metal, and not more than ten in one space or area, unless kept in a separate room inclosed with fire-resistant partitions and doors.

6. All furniture, such as tables, benches and chairs, shall be of metal or other fire-resistant material. No wood shall be allowed except in tops where the under side must be protected with metal.

7. All stockrooms or storage rooms containing inflammable goods must be inclosed to the ceiling with fire-resistant material; no wooden-slat partitions shall be used.

*Other recommendations, not quoted here, relate to the storage and use of inflammable materials, the handling of rubbish and oily waste, the use of automatic springlers, and the use of electricity in preference to gas for illumination.—Editor.

Steam Power Station of the Lehigh Navigation Electric Co; Generation of Energy from Low-Grade Fuels

As has already been briefly noted,* the Lehigh Navigation Electric Co., affiliated with the Lehigh Coal & Navigation Co., has built a large power plant at Hauto, Penn., in close proximity to the collieries and washeries of the latter company, delivering electrical energy to large purchasers in eastern Pennsylvania, but with the possibility of invading New Jersey.

The plant at present, shown in the accompanying figures, contains three turbine-driven, 12,500-kw., 11,000-volt, 25-cycle generators. One more unit of this size is contemplated and at later dates the station may be extended to include also three 25,000-kw. units. It is reported that the present installed capacity of 37,500 kw. has been largely sold. When developed to this ultimate maximum capacity of 100,000 kw., the plant will burn some three tons of low-grade fuel per minute. Therefore, great attention has been paid to the coal- and ash-handling facilities. This fuel comprises the unmarketable small sizes left in the preparation of anthracite, the annual accumulation of which is about sufficient to run the ultimate plant.

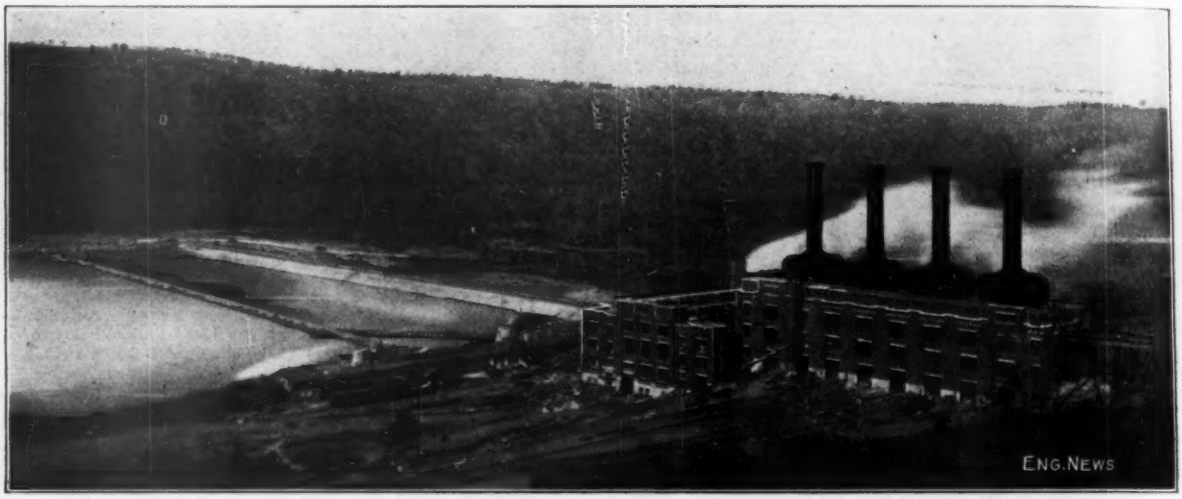


FIG. 1. STEAM-ELECTRIC GENERATING STATION AND CONDENSING WATER RESERVOIR OF LEHIGH NAVIGATION ELECTRIC CO., HAUTO, PENN.

The building proper is of steel and brick. Sills, lintels, coping and base are of rubbed reinforced concrete. The window area has been made large and rolled-steel sash employed. As shown in the accompanying figures the axis of turbine and boiler houses are at right angles, resulting in a T-shaped plant. The site is a sloping river bank; the turbine house fronts the river and the boiler house runs back to the hill, an arrangement obviously best suited to bringing in condensing water and fuel. At present, a single row of eight boil-

*Engineering News, Mar. 23, 1911, p. 367; May 30, 1912, p. 1036.

ers has been installed. Each is of 1000-hp. rating and is a water-tube type (Babcock & Wilcox) of double-ended, five-drum, bent-tube design, superheating the steam 125° at a pressure of 215 to 225 lb. Each boiler has four furnaces with independent masonry setting. Six boilers have been equipped with hand-fired dumping grates with air openings in the grates of the smallest practicable size. Four boilers have slotted grates and two have pin-holed bars, slots and holes being about $\frac{3}{32}$ in. All the grate tops are cross-grooved. For the hand-fired furnaces, the grates are 12x8 ft. each. Two boilers have a trial equipment of automatic stokers. Forced draft is used. Double firebrick arches are thrown over the grates, making the furnace a little like a Dutch oven; this has two purposes, first, to give a hot combustion chamber and, secondly, to form a baffle wall to throw back to the bed any fuel lifted by the draft. The fire-doors lift and are counterweighted.

Coal is brought in standard-gage cars (up to 50 tons capacity) over railroad tracks running into the boiler house above the coal bunkers and boilers, a branch line for this service coming along the hillside. Below the boilers, ashes are dropped into brick-lined steel ash hoppers from which they are discharged directly into standard-gage steel dump cars on low-level tracks. The coal bunkers have a two-day supply capacity, this being considered sufficient in view of the proximity of the mines and washeries.

The main system of looped steam pipes running from the boilers to the turbines, together with the distributing manifolds, valves, etc., are placed in an inclosed gallery parallel to the turbine room. Control of the main valves is from the turbine-room control gallery, so that the valves can be operated without entering the pipe gallery. Two headers (open loop) run from each group of four boilers to the main headers in the pipe gallery. The whole station is laid out on the unit plan; each bank of boilers with its turbine and each generator with its step-up transformers and outgoing feeders can be operated independently or interconnected.

The chief points of novelty in the turbines are the use of a modified Rateau blading (as developed by the Allgemeine Elektricitats Gesellschaft of Berlin) with governors, nozzles and wheels of the Curtis machine. The rotor of each generator carries fan blades for self ventilation. These units have shown a full-load steam consumption of 12.3 lb. per kw.-hr. when operated with 28 in. of vacuum and 100° superheat.

To secure an adequate supply of condensing water for the ultimate plant of 100,000-kw. capacity, a cooling pond and reservoir was constructed (having the additional purpose of extra-supply storage for the Panther Valley Water Co.). For this reservoir, an earth dam was thrown across the Nequehoning River 1800 ft. long, 30 ft. high and 15 ft. wide on the crest with slopes one on two for both sides. The upstream face is protected with concrete slabs, laid with pitch-filled joints. This facing is carried down over the upstream toe to form a concrete cutoff wall.

The watershed above the plant has an area of about 10 sq.mi. and furnishes an annual supply of some 4000 million gallons. The water for condensing is taken from the lower end of this reservoir (at the plant) and after passing through the condensers is discharged into a high-level canal through which it runs back to the head of the reservoir. In this way, the water circulates in a broad sheet and is given ample time to cool. The canal to the head of the reservoir at present is 1500 ft. long. Ultimately, when the full capacity is installed, the canal will be extended about a mile up the valley. The discharge portal at the generating station has a weir with adjustable crest.

The condensers are a rotary-jet type (Leblanc) with one air and two water pumps (centrifugal) on one shaft and all housed in the same casing. The whole condensing unit is hung from the turbine and just clears the basement floor below. Condensing water is lifted by atmospheric pressure so that the condensers have to be primed on starting; a large tank is being built to give a gravity supply for this service. A 445-hp. turbine drives each condenser-pump set.

Between the generating station and the first substation at Siegfried, Penn., are duplicate three-conductor transmission circuits carried on steel towers spaced about 600 ft. apart average; each cable of stranded copper is about $\frac{5}{8}$ in. in diameter and has a section of 250,000 circ. mils. The three cables of each circuit are placed one above the other in a vertical plane 10 ft. apart and

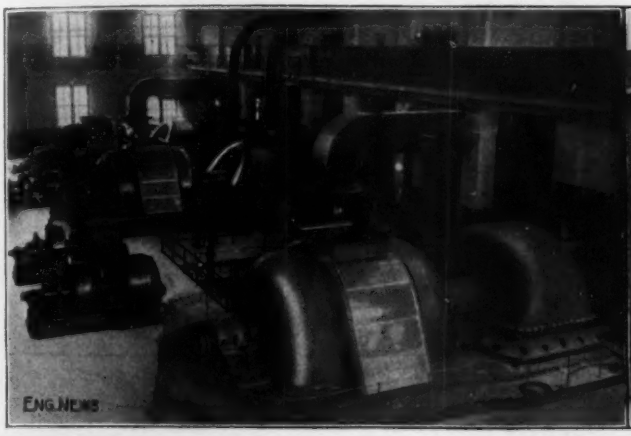


FIG. 2. TURBINE ROOM OF HAUTO STATION

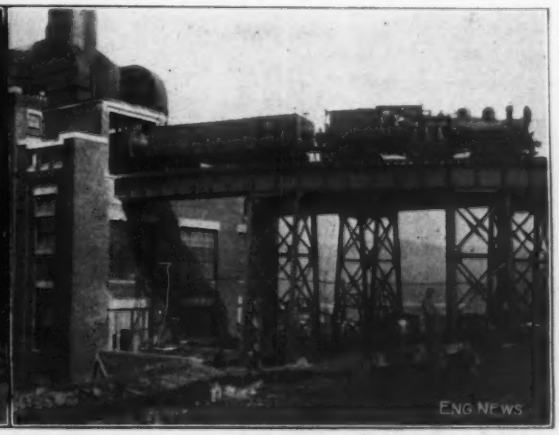


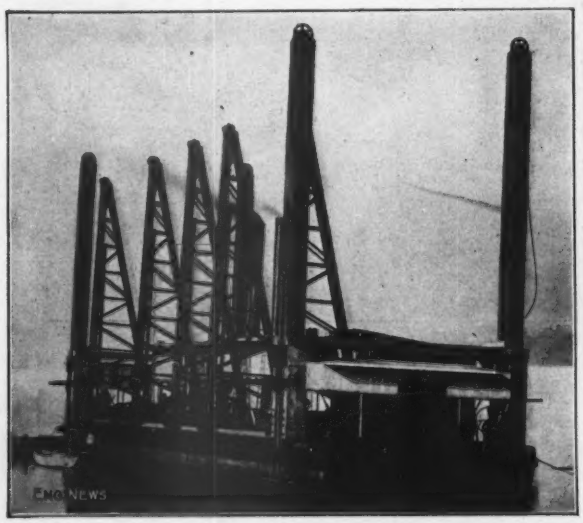
FIG. 3. TRESTLE TO COAL BUNKERS, HAUTO STATION

with the bottom cable at center spans not less than 22 ft. above ground (supported by strings of suspension-type series-disk insulators). At turns and at intervals, about half a mile on tangents, anchor towers are used, designed to carry dead-end stresses and at these places two parallel strings of insulators are used for each conductor. These insulators are also provided with horns to permit lightning discharges to flash past without damage. Two uninsulated ⅜-in. galvanized-steel cables are carried along the tops of the towers, serving as ground wires.

The development was designed and construction was supervised by the firm of L. B. Stillwell, consulting engineers, New York City. The electrical apparatus was furnished by the General Electric Co., of Schenectady. J. W. Ledoux, of Philadelphia, designed the earth-fill dam for the reservoir and supervised its construction.

Drill Boat for Submarine Blasting at Vancouver, B. C.*

A pier in Burrard Inlet, Vancouver harbor, is to be built for the Canadian government, and the contract for this has been let to Henry, McFee & McDonald, of Vancouver, B. C. It includes 150,000 cu.yd. of rock excava-



THE "BURRARD"; A DRILL BOAT FOR DEEP WATER

tion to a maximum depth of 51 ft. below high water. The present depth of water at the site is from 10 ft. at the shore end to nearly 50 ft. at the outer end, so that the thickness of rock to be removed ranges from a few feet at the outer end to over 40 ft. near the shore end. The maximum depth of drilling will be about 53 ft. below high water. The tidal range is about 15 ft.

For this work, the contractors have had built a large drill boat which is said to be the first of its kind on the Pacific coast. It was designed by A. F. Woolley, consulting engineer, of Vancouver, and the hull was built and equipped at that place under the direction of Mr. Woolley and Mr. Odell, manager for the contracting firm. The accompanying view shows this boat, the "Burrard," completed and ready for the installation of the drills.

*From information furnished by the Sullivan Machinery Co., Chicago.

The hull is 118x30 ft., and 8½ ft. deep, with Oregon pine planking 6 in. thick for the sides, 5 in. for the bottom and 4 in. for the deck. There are four bulkheads of timbers 12x6 in. For pulling the boat off and on the range line and getting it into position, there is an anchor and cable at each corner, the cables being handled together or independently by means of a pair of double-drum engines, having two cylinders 6½x8½ in. The machinery equipment is mounted in a large deck house, and includes two boilers 5x14 ft., a 7500-gal. tank for fuel oil, a 5000-gal. tank for feed water, two oil-fuel pumps for the furnaces, two feed-water pumps, and a small steam generator unit for electric lighting. There are also two pressure pumps, one of which supplies the water jets at the drills. The second can be used for the same purpose but is used ordinarily for pumping oil from a barge to the storage tank, and this pump is also connected directly to the pipe lines for fire purposes.

Along one side of the hull are five drill towers, of steel construction, 47 ft. high from the deck. They are mounted on shoes consisting of pieces of inverted 80-lb. rails, the rail heads sliding in channels on timber stringers. The shoes are staggered slightly on alternate towers, so that they will telescope in the channels, thus enabling the towers to be placed close enough to drill holes 5½ ft. c. to c. Heavy setscrews clamp the shoes to the channels while the drill is at work. Each tower has a two-cylinder double-drum hoisting engine which moves the tower by means of a cable which can be hooked to a U-bolt in the deck and led over a sheave to the drum or winch head.

The drills are of the Sullivan submarine pattern, with cylinders 5x8½ in. and extension guides for the piston rods. They can drill holes 40 to 50 ft. deep, and on this work the holes will be 3 in. diameter, but the drills can drive holes 2 to 5 in. in diameter. Each drill requires about 18 hp. for operation. It weighs about 980 lb., while its mounting weighs about 2000 lb. The drill is bolted to a heavy casting or recoil block, having a sheave at the top for the hoisting cable, which passes over double sheaves at the top of the tower.

A feature of the mechanism is a cushion valve which prevents the piston from striking either end of the cylinder when working with throttle wide open. This permits the machine to run practically at full speed in starting a hole in broken rock or on a sloping surface, and also aids in restoring a deflected hole to proper alignment. This valve may be used also in pumping out a hole that has become filled with mud before loading. Steam at 120-lb. pressure is supplied to the drill through 1½-in. pipe with telescopic joints.

At each corner of the hull is a 72-ft. timber spud, 30 in. square, with cast-iron shoe. On the top of the spud is a 30-in. sheave, and on its outer face (about 15 ft. above the deck) is a steel grip to which the ends of the two spud cables are attached. Each spud has a two-cylinder double-drum engine. One cable is led under a deck sheave, up the back of the spud to the top sheave and then down the front side to the grip or attachment. The other cable passes from a deck sheave down to a sheave on the side of the spud and then up to the grip. The cables are attached to opposite ends of the drum, so that as one is hauled in the other is paid out. The cables are long enough to bring the spuds to a bottom bearing in 52 ft. of water.

Street-Department Organization and Methods, Oakland, Calif.*

The department under the Commissioner of Streets of Oakland, Calif., was completely reorganized during the year 1911-1912, and the resulting efficiency has been such as to furnish a model for similar organizations in other cities. Oakland has a commission-plan form of government, adopted in 1912. In reorganizing the city engineering department under the new charter no radical innovations were attempted. With the exception of two new ordinances the work was accomplished by revising existing ordinances to conform to the new type of city government.

New Ordinances—The first of these new ordinances requires that a permit be obtained from the Bureau of Permits and Licenses by any person desiring to construct a cement sidewalk. Before obtaining such permit, the person must deposit with the city the sum of $200 as a guarantee that good work will be done. This deposit remains with the city for one year after the completion of any sidewalk work done by the person making such deposit, during which time, if defects appear, the Superintendent of Streets notifies the person to remedy them within ten days, and if the order is not complied with, the Superintendent of Streets has the work done and the cost is deducted from the $200 on deposit. The ordinance sets forth in detail the specifications under which cement walks must be constructed and provides that no sidewalk other than of cement concrete, 6 ft. in width, shall be constructed without permission from the city council.

The second new ordinance, known as the excavation ordinance, prohibits excavating within public streets without a permit therefor issued by the Bureau of Permits and Licenses upon a proper application by the Superintendent of Streets. The person desiring a permit to excavate first places a deposit with the city, the sum depending on the kind and amount of pavement disturbed; or he may maintain a general deposit of $1000 for all excavations excepting for side sewers, for which work a deposit of $200 is required.

Special or general deposits are a guarantee that the work will be done properly, and remain with the city until one year after the completion of the work covered by such deposit.

Necessary repairs to the street caused by an excavation, and not made by the person responsible upon notice, are made by the Superintendent of Streets, and if not paid for within a reasonable time, the cost is deducted from the deposit covering the excavation, and no further permits are issued on that deposit until it has been brought up to the full required amount.

This ordinance sets forth in detail the method of conducting the work and the specifications for replacing the street surface.

The Street Commissioner states that the effect of these two ordinances has been good, for the reason that a record is made and kept of all work, and the person responsible for it. A cash deposit has been found superior to a bond as a guarantee, and it has not been necessary as yet to deduct from a deposit to make good a default.

*Based on Annual Report of W. S. Backus, Commissioner of Streets of Oakland, Calif., for 1913.

Organization and Methods of Procedure

The department is divided into the Department of Streets proper and the Engineering Department, both under the control of the Commissioner of Streets and under the direction of the Superintendent of Streets, who is ex-officio City Engineer.

The Department of Streets is again divided into the Clerical Division, Construction Division and Maintenance Division. The Clerical Division is under the control of the Chief Assessment Clerk and the Chief Clerk. The Construction Division is under the direct charge of the Assistant Superintendent of Streets, who has supervision of all new street and sewer work. The Maintenance Division is under the direct control of the Deputy Superintendent of Streets and Assistant Deputy Superintendent of Streets, who are responsible for all maintenance and repair work and the equipment for carrying on the work.

The Engineering Department is under the Deputy City Engineer and not only handles the engineering work of the Department of Streets, but also for the Harbor Department and all other departments of the city.

Drawing of Contracts—All contracts and bonds are drawn and signed in quadruplicate on printed forms of legal size, each form having a 1½-in. margin. On three of the forms the margin is torn off, leaving the contract

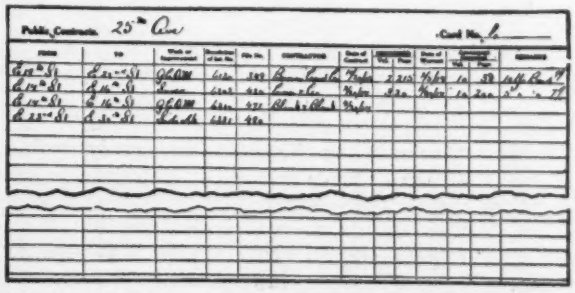


Fig. 1. Sample of Card Index Giving History of Street

of legal size. The fourth copy is punched for a loose-leaf binder and makes the recorded copy as required by law. Under this system all four copies may be filled in at one time on the typewriter, the sheets all being the same size.

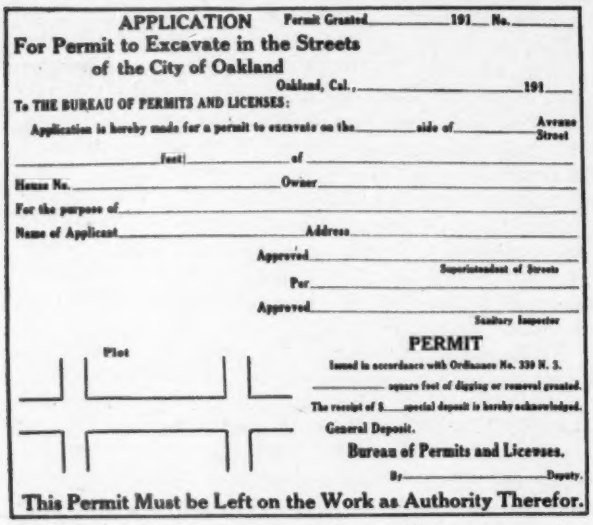
Indexes and Filing System—A complete engineering history of every street is kept. Such records are kept on cards like the one shown, Fig. 1. As soon as a street proceeding is started, or an action of any kind is taken that may become a lien on a property, a number is given to the proceeding, and proceeding is entered on the card as shown.

By this card index the proceedings may be traced as to progress, and when completed the card shows the full history of the job and reference to all records in connection with it. Index cards on private contracts, street openings, city contracts and supplies with proper headings and on different colored cards are made in the same way. Every street affected under a proceeding is indexed.

At the time an index card is started, an envelope of a size to hold legal documents is marked with the number of the proceeding, and with a brief description of the work. In this envelope all contracts, plans and papers

other than the bound records are kept, so that any paper pertaining to the work is quickly located.

Under this system of indexing and filing, about one-third of the previous clerical labor has been eliminated, and the office force is enabled to answer promptly and intelligently all inquiries as to the work on a street, or whether there are any liens on a piece of property, etc.



APPLICATION Permit Granted ____ 191__ No. ____

For Permit to Excavate in the Streets of the City of Oakland

Oakland, Cal., ____ 191__

To THE BUREAU OF PERMITS AND LICENSES:

Application is hereby made for a permit to excavate on the ____ side of ____ Avenue Street

____ feet ____ of ____

House No. ____ Owner ____

For the purpose of ____

Name of Applicant ____ Address ____

Approved ____ Superintendent of Streets

Per ____

Approved ____ Sanitary Inspector

Plot

PERMIT

Issued in accordance with Ordinance No. 339 N. S.

____ square feet of digging or removal granted.

The receipt of $____special deposit is hereby acknowledged.

General Deposit.

Bureau of Permits and Licenses.

By ____ Deputy.

This Permit Must be Left on the Work as Authority Therefor.

FIG. 2. SAMPLE APPLICATION FOR EXCAVATION IN STREET

EXCAVATIONS IN STREETS

PERMITS—As noted in the ordinance already quoted, no excavation can be made in a street by private parties except upon application approved by the Superintendent of Streets. The standard form of application, Fig. 2, requires an accurate statement of just what is to be done. These applications are made in triplicate. All three copies, properly approved by the Superintendent of Streets, are taken to the Bureau of Permits and Licenses, where the necessary deposit of cash is made and the permit granted. The original is returned to the Department of Streets, and a duplicate to the Department of Health.

WORK ORDERS—As soon as the original permit is returned a numbered work order is made out in duplicate on printed forms. The original work order is then given to an inspector in charge and the duplicate work order is held in the office for check against the inspector. As soon as the work order is issued the permit is filed by date. When the work order is returned by the inspector, reporting that the street has been properly repaired, it is filed by street.

If the excavation has been made in a paved street, another work order is at once made in duplicate on a regular printed form, which is given to the Assistant Deputy in charge of pavement repairs. The Assistant Deputy has the pavement repaired as soon as possible and files the cost with the accounting department, by which the necessary bills are rendered and collections made. Should the party not pay promptly, the charge is taken from his deposit, and no more permits are issued to him until he makes good his deposit.

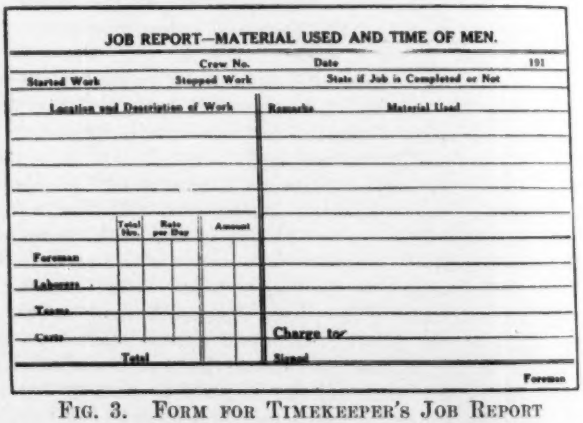
At the expiration of the one year for which the cash deposit guarantees the repairs, the original permit is taken from the files and a new work order is made for the inspection of the street. If the report of the inspector is satisfactory, the Bureau of Permits and Licenses is notified and the deposit and records are released. If the street is not in proper repair on account of settlement, the Street Department puts it in shape, has the charge collected, and then releases the Bureau of Permits and Licenses' deposit and records.

COMPLAINTS—All complaints are made out in duplicate on blank forms. The original of the complaint card is given to the deputy in charge of the work, who makes out a work order to the proper crew, where work is necessary, or to an inspector for attention and report. The duplicate is filed with the clerk in charge of complaints to follow up and see that the complaint receives prompt attention. When a report is made, the original is filed by street and the duplicate destroyed.

KEEPING UP EFFICIENCY OF CITY LABORERS

TIMEKEEPING—The timekeeper visits every crew in the Maintenance Division every day, and sees what men are at work. Every morning he gets the location of the different crews from the district deputies or crew foremen on cards printed for that purpose. In addition to his taking time he also receives a weekly report from the district deputy giving the time of each man. This report also gives a detailed report of the class of work done, materials used, time on each class of work, and other statstical data necessary for the accountant. By checking this report against the time the timekeeper himself has already taken, he can correct any errors before they reach the accountant.

From the general foreman in charge of the city labor the timekeeper gets and fills out ordinary time cards and special job report cards (Fig. 3). A similar record is kept of street sprinklers. From the various mechanics employed at the corporation yard, garage, etc., he receives a daily job report similar to the one used by roving crews,



JOB REPORT—MATERIAL USED AND TIME OF MEN.

Crew No. ____ Date ____ 191

Started Work ____ Stopped Work ____ State if Job is Completed or Not

Location and Description of Work	Remarks	Material Used

	Total No.	Rate per Day	Amount
Foreman			
Laborers			
Teams			
Carts			
Total			

Charge to ____

Signed ____

Foreman

FIG. 3. FORM FOR TIMEKEEPER'S JOB REPORT

which gives a check on the time and on the work accomplished.

At the end of the month a summary is made of the time of all the men on a monthly time record. From this the accountant gets his time charges segregated in the way in which he wishes to make the charges. From this monthly record and the weekly reports are made the book charges and the statistical records on maintenance and repair.

The use of the new forms and methods has reduced the clerical work at least one-half. The timekeeper is

not only able to keep a better check on the laboring force, but is given more time to check its efficiency. The forms are also such that comparisons of different districts, or of the same crew or man on different jobs, are easily made.

The timekeeper has established in connection with his efficiency work a system of "book suspensions." Before this system was inaugurated it was the rule to give a man an actual suspension for infraction of the rules. Under the new system he is not actually laid off, but a charge is made against his name in a ledger kept for the purpose. When the charges reach 90 days the man automatically discharges himself. These "book suspensions" may be worked off by a clean record on a sliding scale. Flagrant cases may receive an actual suspension or discharge.

Credit on the record is also given for meritorious service, such as filling a higher position satisfactorily during temporary disability of higher classed employees, using judgment and ability in meeting emergencies, etc.

When a case of merit or demerit arises in the working force, it is reported to the timekeeper and he makes a thorough investigation and reports in writing to the Superintendent of Streets, who writes a letter to the man, giving cause for discipline charge and calling attention to the fact that an accumulation of charges will lead to a separation from the service. In case of meritorious conduct, he writes the man a commendatory letter and encourages him to further efforts. No cases are acted on except by the Superintendent of Streets.

Preparation of the Budget

The budget estimates are made in detail by taking a comparative statement of ledger segregations for the three years previous. From this is figured the cost for the year, allowing for increase in work, difference in cost of material, etc. In this way, all estimates can be checked by the Commissioner of Revenue and Finance and the Auditor, in making their recommendations. It is the custom to check out these estimates and allow the department a gross sum, so that emergencies may be met and work done to the best advantage.

When the budget is finally fixed by the Council, the different heads of departments are called together and every item is gone over and pruned to the minimum, leaving any surplus to be credited to the oiling of streets, resurfacing of asphalt streets, etc. The segregations are then entered on the books of the department and copies given to each head. Should an item be overrun or new work develop that is not provided for, the head in charge of that division must in some way provide for the money by cutting expense on some other line. Monthly balances of amount spent and balance in the segregated funds are supplied by the accounting department so that a complete check is kept at all times.

The Commissioner of Streets of Oakland is William T. Baccus, and the Superintendent of Streets and ex-officio City Engineer is Perry F. Brown.

Suction Lifting Devices, as a safety measure are used for feeding sheet metal to punch presses in the shops of the Westinghouse Electric & Manufacturing Co., Pittsburgh. These are hollow hand rods or sliding frames carrying flat dished "sucker plates" which grip the metal sheets. Rubber hose leads to the suction pipe lines. Various convenient control valves are employed for grip and release.

Report on Chicago Sewage Disposal and Water-Supply Problems

A preliminary report on sewage disposal and water-supply at Chicago, with particular reference to the Chicago Drainage Canal, has been submitted to the Harbor and River Improvement Committee of the Chicago Real Estate Board. The report was dated May 1, 1914, and was made by a board of experts consisting of George A. Soper, of New York City, John D. Watson, of Birmingham, England, and Arthur J. Martin, of London, England. The report was made after two weeks' investigation on the ground and fills ten small printed pages. Speaking of the Chicago water-supply, the experts say "it appears to have been shown [by others] that Chicago has one of the cleanest and purest water-supplies of any large city in America," although more protection in the future is advised.

An inspection by the Des Plaines and Illinois Rivers showed that at the time "the water was offensively polluted with sewage as far as Ottawa [Ill.]—85 miles from Lake Michigan."

The experts are of the opinion that sewage disposal by dilution at Chicago will prove to be insufficient and that "ultimately it will be necessary to treat practically all of the sewage before it is discharged; that diverting the sewage from the lake and extending or altering the waterworks intakes would not render water filtration unnecessary;" but that "the conditions of sewage disposal and water-supply which now exist are not so unsanitary as to call for improvements which will involve immediate and large expenditures of money. . . The great need is for a definite worked out sanitary policy for the future . . . . preparation of plans should be undertaken immediately."

Finally the experts lay down "certain principles and lines upon which it may be desirable to proceed." These follow:

1. The principle of diverting the sewage from the lake should be adhered to, in spite of any degree of sewage purification or water purification which may be employed.

2. Full advantage should be taken of as large a volume of diluting water as may be obtainable from the lake, in order that the cost of finally disposing of the sewage may be reduced to a minimum.

3. Thorough and exhaustive study of the capacity of the drainage channel to absorb and oxidize sewage should be made in order that full advantage may be taken of the opportunities thereby afforded for completing whatever process of sewage treatment may be employed as a preliminary measure of disposal.

4. It is desirable to concentrate as much of the sewage as practicable at a point beyond the built-up sections of the city and in the vicinity of the drainage channel, where the sewage can be treated sufficiently to permit the effluent to be discharged without serious danger of offense.

5. To avoid excessive cost in the construction of intercepting and collecting sewers, and in order to relieve the drainage channel as far as practicable, it will be desirable to treat the sewage of some parts of the city in the areas in which the sewage is produced, and not carry it to the central disposal station. The number and location of these plants can be determined only after careful consideration is given to the quantity of sewage to be disposed of, the facilities which are afforded for disposing of the effluent, the sanitary requirements, the method of treatment available in the locality and the cost.

6. Practically no sewage should be discharged into the Chicago River nor the drainage channel, without some form of treatment, except in times of storm, when suitably located overflows will be permissible. The sewage should, for the most part, be collected by a system of intercepting sewers

running along the water front and extending to the central disposal station.

7. The minimum requirement in the treatment of the sewage at the main station should be the removal of the suspended solids. Screens and settling basins now afford the most practical means by which the suspended matters can be removed.

8. Screens and grit chambers afford the most effective means of treatment which it is permissible to employ in the closely built-up sections of the city. Owing to the odors that occasionally may be produced, and because of the antagonistic popular opinion which would, in all probability, be aroused, it will not be advisable to locate settling basins or more efficient processes of sewage treatment in the built-up sections of the city.

9. With the growth of population and the development of the public opinion it is probable that a greater purification of the sewage will be called for in time than is possible by screening and sedimentation. This probability should be anticipated as far as possible and the work so designed as to permit of extension and improvement without excessive cost.

10. Sanitary standards of cleanness for the water should be prepared to serve as a guide toward which the work of disposing of the sewage and protecting and improving the drinking water should tend. The standards should be interpreted liberally and with due regard to the modifying circumstances imposed by local conditions.

11. Different standards for different places should be prepared, including one for the lake water in the vicinity of the intakes, another for the Chicago River and its immediate tributaries, and a third for the drainage channel at its discharge into the Desplaines River.

12. The standard for the drinking water should contain specifications as to its bacterial condition and turbidity; that relating to the river should have reference to the appearance of the water and its odor, and that which refers to the discharge of the drainage channel to the suspended solids and putrescibility.

13. In regard to the condition of the water discharged from the drainage channel into the Desplaines River, the ultimate end should be a discharge which will not render the water of the river offensive or materially more difficult for the municipalities upon it to make, and keep, clean.

14. The arms of the Chicago River which have no present or future value for navigation, and which are now in a foul and stagnant condition, should be filed in.

15. Pending the construction of the intercepting sewers and sewage-treatment works, the drainage channel and river should be kept free from putrefying deposits by dredging and the dredgings should be disposed of otherwise than by dumping into or near the lake.

16. The sites for the treatment works should be determined upon as soon as possible, and sufficient land should be reserved to meet the future requirements which can be foreseen and afford a liberal margin for contingencies.

17. All considerable flows of especially foul liquids, such as those from the stock yards, should receive special treatment before they are discharged into the Chicago River or the drainage channel. The cost of treating these wastes, above the cost of treating the same volume of sewage from the rest of the city, should be borne by those who produce the wastes.

18. The disposal of the sewage in the Calumet territory is a local problem which can and should be solved by the construction of one or more purification plants.

Water Treatment for Railways*

By R. C. Bardwell†

The 1914 report of the Committee on Water Service of the American Railway Engineering Association shows that on six representative trunk lines of the Middle West there are now in service 237 complete water-treatment plants and 111 soda-ash partial-treatment stations, ranging from five complete plants on one road to a maximum of 112 on another, and from no soda-ash plants on several to 86 on one. Besides this, several railways arrange for placing soda ash in the engine tanks at the terminals. This is conducive to foaming conditions, but the economy derived from the scale removal more than justifies the foaming complaints.

On the Missouri Pacific Ry., 45 complete water-softening plants are in operation, the majority being on the hard waters west of the Missouri River. The average amount of water treated per year, reducing the hardness so that it will form practically no scale, is 1,602,000,000 gal. The total average amount of scale removed from this water is 5,537,000 lb. The total annual cost for the above treatment, including chemicals, additional supervision necessary, maintenance, interest and depreciation on plants, is about $65,000. Conservative figures show that this expenditure effects a net saving of about $105,000.

On one terminal alone approximately 18,000,000 gal. of water are treated monthly, eliminating 5 lb. of scale per 1000 gal. for a total of about 80,000 lb. per month. The cost for chemicals for this is about 4c. per 1000 gal., or a total monthly bill of about $720. The length of life of flues using the raw water before the installation of the softening plants was from 8 to 12 months, with serious trouble on account of frequent leaks. The locomotives now using the treated water average 18 months between shopping and the trouble with leaky flues is practically eliminated.

So far the development of water softening on a large scale has centered around lime and soda ash as being the chemicals which produce the results for the least cost. However, barium hydrate is the ideal reagent on account of its leaving no detrimental byproducts, as in the case of soda ash. So far, the expense has retarded its development. Numerous boiler compounds have been tried by a few railways, but investigation would show that even where the work desired was done the cost greatly exceeds that of the recognized methods. Inert powdered graphite is now being exploited as a cure for scale troubles, but its economical merits are yet to be proved.

The "sunlight on corrugated aluminum" patent which was supposed to render the scale inert in the water without removing it chemically has been tried at several points in this section and seems to have proved unworthy. The permutitt water softener, the artificial zeolite, has the objection in railway work of replacing the incrusting carbonates with sodium carbonate. That is, waters which are sufficiently hard to warrant the expense of treatment as a rule contain such an amount of incrusting carbonates that if replaced by sodium carbonate the waters could not be used on account of foaming properties. Therefore, it would seem that common lime and soda ash will continue to remain in service.

Unbalanced Engineering Salaries—At the time the information [for the report on the compensation of engineers for the American Society of Civil Engineers] was being collected, the writer was a member of an engineering organization employing about 20 men in the grade of transitman or higher, of whom two were members of the Society and reported their salaries to the Committee. These two men constituted the upper 10% of the entire force and their average salary was 204% of that of the remaining 90% of nonmembers. While somewhat more experienced than their fellows, it was by no means in such a proportion and it seems safe to assert that their salaries were at least 150% of what would have been attainable under similar conditions by the average engineer of equal length of practice.—A. I. Stiles, before the American Society of Civil Engineers.

*Abstract of a paper read at the annual meeting of the Illinois Water Supply Association, at the University of Illinois, Mar. 9-11, 1914.

†Chemist, Missouri Pacific Ry., 627 Midland Building, Kansas City, Mo.

A 100-Ton Electric Wrecking Crane*

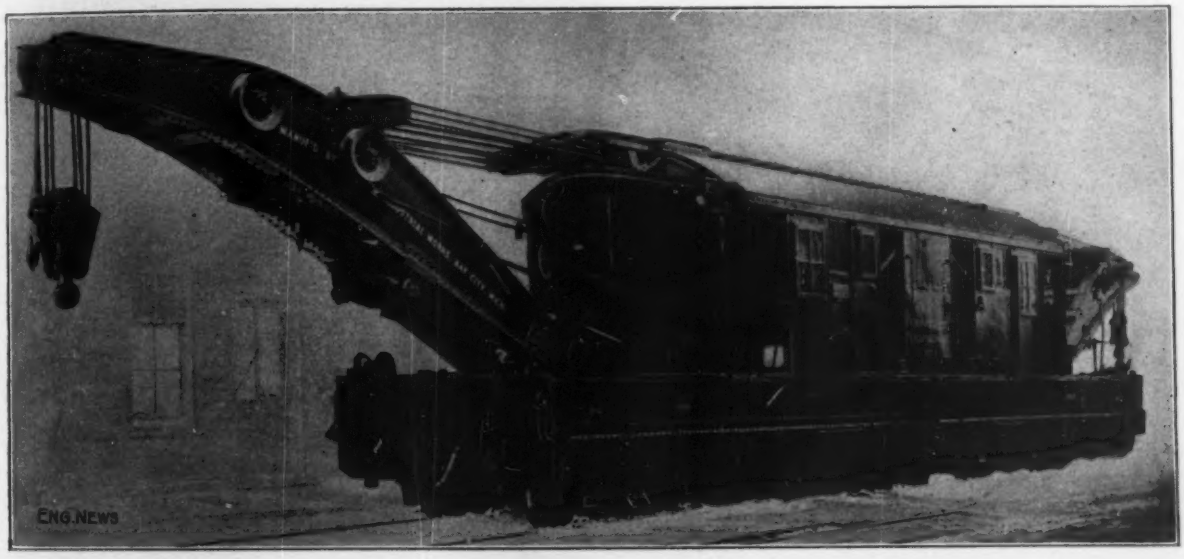
The New York Central & Hudson River R.R. has just received in New York City for use in Grand Central Terminal district, a wrecking crane of unusual size and proportions. This is a double-end electric wrecking crane, with independent 100-ton (capacity) cranes at each end, the whole being especially designed for underground clearances and conditions. While primarily designed to meet Grand Central Terminal conditions, it is also adapted for use on the main line of the electric division, where operating conditions and clearances are such as usually obtain on steam roads. It is virtually a powerful electric locomotive as well as a crane and is completely equipped for independent operation.

The handicaps in the design of this crane were unusual. Great capacity had to be developed with little head room for raising the boom and small side clearance for slewing. Excessive concentration of wheel loads was prohibited.

The massive construction resulting is shown by the accompanying figure. The car body is 67 ft. long, with a wheel base of 51 ft., and is carried on two compound trucks, each made up of two four-wheel trucks. A cradle on which the car body rests allows the compound trucks, as well as each single truck, freedom to swing when taking curves. Complete air brakes are provided, also a hand brake wheel at each end. There is a system of air-operated valve-controlled telescopic outriggers or jack beams, to add stability during heavy lifting and to distribute the load over a greater area.

At each end of the car is a complete independent crane, with a structural mast and boom, accurately turned roller path and rollers, and the slewing mechanism. All of the motions of operation may be performed independently, and simultaneously, with loads up to the capacities of the motors. All clutches are air operated. At each end of the cab are the operating levers for that end, but the propulsion may be controlled from either end. The electrical equipment is noteworthy for its power and flexibility. Six principal motors with a total of 1100 hp. are used, for operating the crane as follows: Four of 200 hp. each, for propelling; and two of 150 hp. each, for hoisting and for operating the machinery. The propelling motors are direct connected to the axles of the compound trucks, two at each end of the car. They are arranged so that all four may be used for traveling, or if desired, only the two at either end. They are capable of operating safely on fluctuations of line voltage between 300 and 750 volts, direct current.

For intermittent and emergency service, as might be required with the third rail out of commission, or when suitable cable connections could not be made with a feed line, there is installed on the crane a high-capacity storage battery. This has 230 cells giving 75 amp. for eight hours and discharging with a maximum rate of 350 amp.



100-Ton Electric Wrecking Crane; N. Y. C. & H. R. R.R.

in two hours. At each end of the car is a switchboard with lamps and instruments, including an ampere-hour meter for the storage battery.

This crane may be dispatched at high speed under its own power to the scene of an accident anywhere on the electric division. The procedure, in case of a wreck underground, would be somewhat as follows: If possible, the wreckage would be lifted clear of the track and the crane would then back out with it. If the crane could not raise the damaged equipment off the track, either on account of lack of head room or because of the size of the piece, one end would be lifted with the main hoist and with the auxiliary hoist, a special truck would be placed in under. The crane would then drag away the load.

The operation of hoisting is by means of a train of cut-spur gearing. There is a brake of sufficient capacity to hold the maximum load in any position, or to lower it at a low rate of speed. A combination clutch and brake is provided for dispatch lowering of the block. In addition, there is a ratchet and pawl of ample strength

*From information furnished by the Industrial Works, Bay City, Mich., designers and builders of the crane described.

to hold the maximum load when the clutch is disengaged and the winch heads are in operation. These winch heads are on either side of the crane, are of 25 tons capacity and are independent in operation of all other mechanisms. The auxiliary hoist is arranged to operate at the same radius as the main block, or at different points on the boom. The boom-hoist or radius-varying mechanism may be operated with the maximum load.

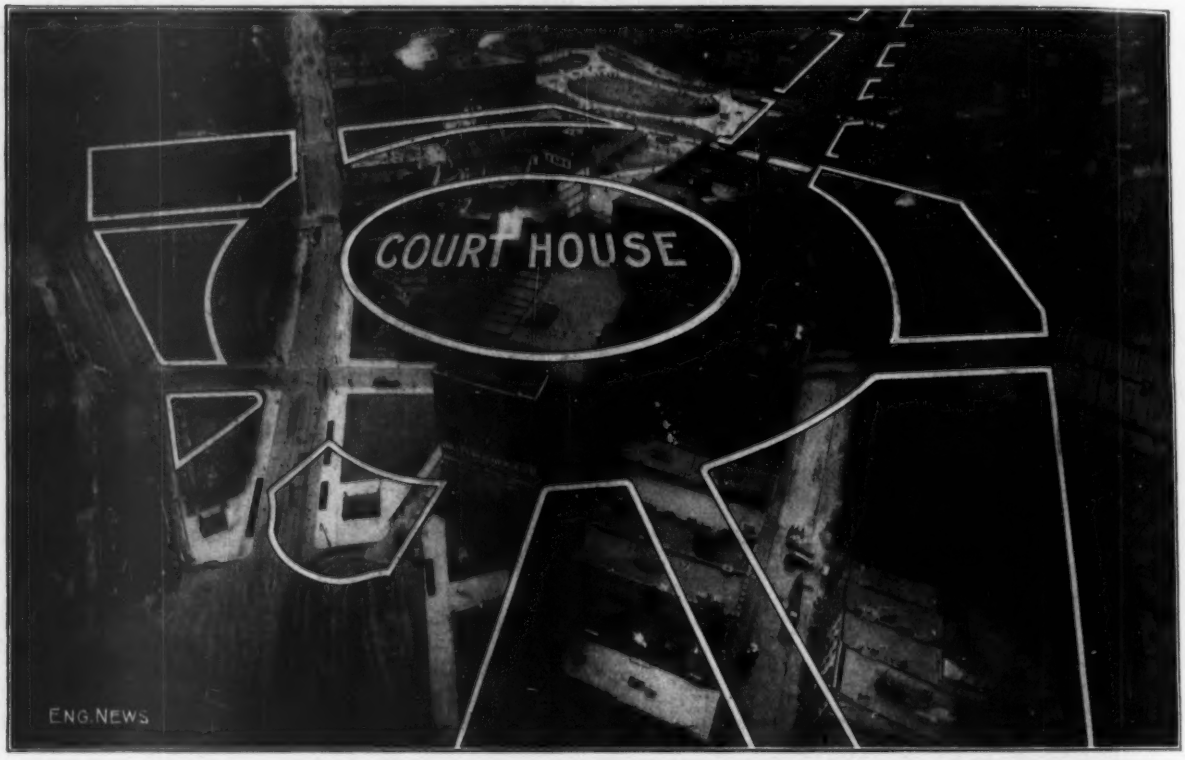
The crane was guaranteed to haul an 80-ton rolling load at 25 mi. per hr. on level and at 15 mi. per hr. on 2.7% grade. (On test the 80-ton load was carried at 34 mi. per hr.) The addition of a 50-ton suspended load was guaranteed to reduce the speed on level to not less than 12 mi. per hr.

The crane capacities designed for were (on solid-foundations with outriggers), (a) 100 tons at 24-ft. 2-in. radius straight ahead or 6 ft. 6 in. either side of center; (b) 100 tons at 22-ft. radius straight ahead or 12 ft. either side of center; (c) 100 tons at 13-ft. 8-in. radius swinging 180°. Without outriggers (a) is reduced to 50 tons straight ahead and (c) to 25 tons. This crane was designed and built under specifications prepared by a committee for the New York Central & Hudson River R.R., comprising C. H. Quereau, Superintendent of Electrical Equipment (Chairman), H. A. Currie, Assistant Electrical Engineer, and B. J. Buell, Wrecking Master.

Lightning Is the Second Great Cause of Forest Fires, the first being the railways, according to the United States Forest Service. In the mountains of southern California, Arizona and New Mexico, succeeding long droughts, electrical disturbances known as "dry thunder storms," are expected. The Forest Service, therefore keeps its maximum fire-fighting strength in those regions during this period.

The New Court House Site, New York City

What city planning means in an established community is well illustrated in the accompanying view showing the proposed site of the new court house in New York City. The view is taken from the roof of the new Municipal Building in Manhattan looking northeast. Lafayette St., under which runs the old Interborough subway, is the street running north at the extreme left; Center St., the line of the new bridge-connecting subway, is in the center of the picture running north and Pearl St. is the lowest cross-street shown. At the upper right center is Mulberry Bend Park, the site of the once notorious Five Points and at the upper left is the Tombs, the city's equally notorious prison.



SITE OF NEW COURT HOUSE, NEW YORK CITY

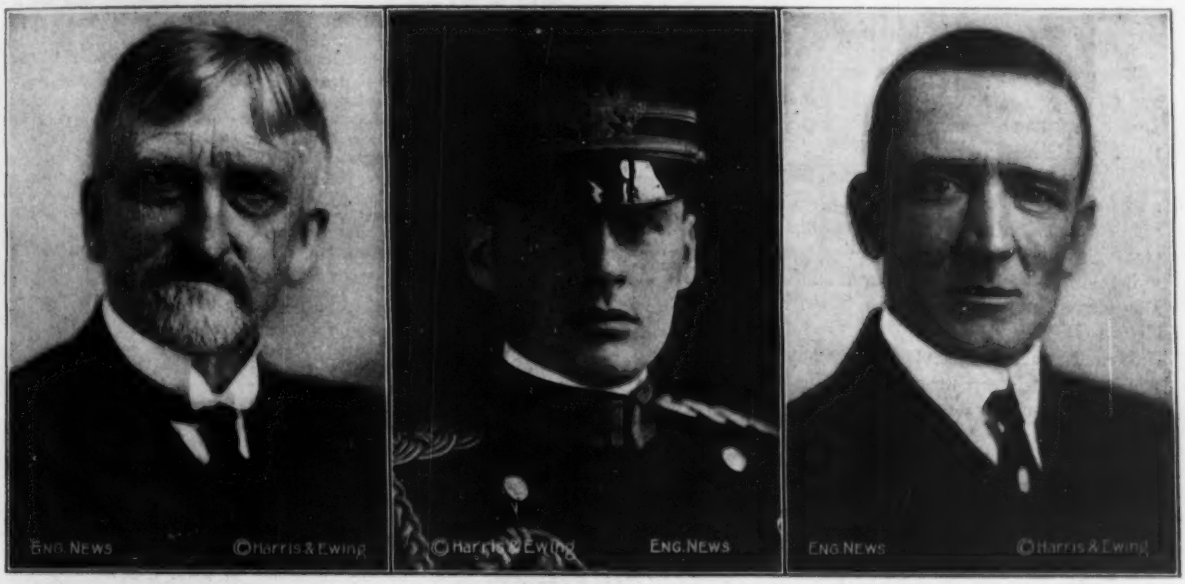
The new court house, a circular building designed by Guy Lowell, and accepted by the justices of the Supreme Court only after many months of deliberation, is to be located in the area shown in the view, and the remaining outlined area is to be devoted to parking and new streets. As can be readily seen, the district is completely built up with structures ranging from two-story brick houses to the 10-story modern steel-frame building in the immediate foreground in which the Hill Publishing Co., the publisher of ENGINEERING NEWS, has been located for some years past. All of these structures must be torn down; in fact, the view shows quite a number already demolished or in process of demolition.

The plan as indicated herewith is the latest development of the court-house plans and is to be presented to the Board of Estimate next week by President MacAneny of the Board of Aldermen. The new scheme

merely transfers the site somewhat farther east than it originally stood. There seems to be small doubt of its being adopted. As soon as it is adopted, actual construction will be started and the completed building and surrounding parking should be ready in about five years.

The Alaskan Engineering Commission

President Wilson's appointment of the members of the Alaskan Engineering Commission was noted in our Personal Columns of last week. This commission is appointed at present, we are unofficially informed, for settlement of survey and location problems only, but that it will probably continue with the work of construction later, seems a foregone conclusion. No formal order was issued by the President for constituting this commission, or board of engineers, and it is generally understood the Secretary of the Interior bears the same relation to it that the Secretary of War has had to the Isthmian Canal Commission.



WILLIAM C. EDES LIEUT. FREDERICK MEARS THOS. RIGGS, JR.

THE ALASKAN ENGINEERING COMMISSION

WILLIAM C. EDES

The chairman of the commission, William C. Edes, is a railway locating engineer of ripe experience. He was born in Bolton, Mass., Jan. 14, 1856, and graduated from the Massachusetts Institute of Technology in 1875. For four years, 1878 to 1882, he was with a railway location party of the Southern Pacific Ry. in Arizona, New Mexico and Texas. From 1886 to 1896, he located and had supervision of construction of many miles of the Southern Pacific system in the west coast region.

Mr. Edes was Chief Assistant Engineer of the San Francisco & San Joaquin Valley R.R. from 1895 to 1900, under W. B. Storey, then Chief Engineer of that railway, now Vice-President of the Atchison, Topeka & San Fé Ry. During the following five years he had charge of location work for the reconstruction of some of the Southern Pacific system mountain lines, including the Central Pacific Ry. from Rocklin to Truckee, Calif.

After two years as District Engineer of Maintenance-of-Way of the Southern Pacific Ry., he returned to difficult mountain location work, for which his long experience peculiarly fitted him. As Chief Engineer of the Northwestern Pacific R.R., from 1907 until his recent appointment to the Alaskan Engineering Commission, Mr. Edes has been engaged in locating and constructing a railway through difficult mountain cañons btween Willets and Shiveley along the Eel River in western California.

LIEUT. FREDERICK MEARS, U. S. A.

Frederick Mears was born May 25, 1878, at Omaha, Neb. He was educated at Gonzaza College, Spokane, Wash., and at the Shattuck School in Minnesota.

At 19 years of age he entered the service of the Great Northern Ry., as a rodman on the Park Rapids extension in Minnesota, and later served as a leveler on the location of the Coon Creek cutoff. In 1898, he was promoted to be Assistant Engineer and was engaged in the location of the Kootnoi Valley R.R. and the Bellingham & Nelson R.R. in northern Idaho and British Columbia.

In 1899, he enlisted in the United States Army and was sent to the Philippine Islands where he soon saw active war service in the pacification of the natives. He received a commission as Second-Lieutenant in 1901. On his return to this country, he entered the United Staff College at Fort Leavenworth, Kan., in 1903, and graduated two years later, in 1905. During leave of absence in the summer of 1905, Lieut. Mears spent four months as Resident Engineer on construction work for the Chicago, Rock Island & Pacific Ry. in Arkansas.

In May, 1906, he was sent to the Isthmus of Panama at the request of John F. Stevens, then Chief Engineer of the Panama Canal, with whom Lieut. Mears had been associated in his work on the Great Northern Ry. Lieut.

Mears' first detail at Panama was as track foreman. He was soon promoted to be Assistant Engineer and had charge of the relocation of the Panama R.R. From 1907 to 1909, he was Resident Engineer and Engineer of Construction.

Since Dec. 1, 1909, Lieut. Mears has been Chief Engineer of the Panama R.R. and has had charge of maintenance and of the construction of the relocated high-level line. Since Dec. 1, 1913, he has also been General Superintendent of the Panama R.R. and Steamship Line, in charge of operation, maintenance and construction on the Isthmus. The work done under his supervision at Panama included the reconstruction of almost the entire railway, the design and construction of the Atlantic terminal docks at Colon, the location survey in 1910 for the Panama Government of a railway from the Canal Zone to the Costa Rican border, and the construction of numerous structures for the Panama R.R.—amounting to over $11,000,000 in engineering work on the Isthmus during his eight years there.

THOMAS RIGGS, JR.

Thomas Riggs, Jr., was born Oct. 17, 1873, in Howard County, Maryland. He was educated at the Emerson Institute, Washington, D. C., and at the School of Science, Princeton University.

His early experience in engineering work was in mine and land surveying. In July, 1906, he passed the civil service examination for Topographic Aid, United States Geological Survey, but he never served under this appointment. Instead, he was transferred to the Alaska Boundary Survey, under the State Department, as Assistant Engineer.

Mr. Riggs has been continuously engaged with the Alaska Boundary Survey until the close of last season when the work was completed. During this period, the 141st meridian was surveyed and marked from Mount Elias to the shores of the Arctic Ocean, a work which involved great hardships and considerable danger. He was the first man to use horses for transportation purposes north of the Porcupine River, and their appearance caused great astonishment among the Indians and Esquimaux of the far north.

In 1911 and 1912, an epidemic of smallpox broke out among the Indians on the Porcupine River, which was so successfully handled by Mr. Riggs with the assistance of the Canadian and United States authorities that only one death occurred. He is thoroughly familiar with Alaskan life and conditions as well as with Alaskan topography and climate.

Mr. Riggs was married in 1913 to Miss Renée Coudert, daughter of the late Frederick R. Coudert, a prominent banker of New York City, who was Commissioner for the United States on the Bering Sea Arbitration.

NEWS NOTES

Floods Washed Out a Large Steel Railroad Bridge on the Chicago, Rock Island & Pacific Ry. across the Canadian River at Geary, Okla., on the afternoon of May 3. Six men who were on the bridge were swept into the river, three being rescued. Several other and smaller bridge washouts are reported. It is claimed that the Rock Island bridge was wrecked by driftwood from the wrecked structures upstream.

The Criminal Prosecutions of the Three Trainmen indicted for involuntary manslaughter in connection with the wreck of the Bar Harbor express on the New York, New Haven & Hartford R.R., at North Haven, Conn., Sept. 2, 1913 (see "Engineering News," Sept. 11, 1913), have ended. The flagman Murray, who went back but about 300 ft. from the rear of his train, and who pleaded guilty, is at liberty on a suspended sentence of 1 year in jail. The engineman Miller was acquitted on May 6, and on May 7 the state dropped the case against the conductor Adams.

A State Flood Commission has been appointed in Indiana by Governor Ralston, made up of one representative from each congressional district of the state. At the meeting of the Commission for organization on Apr. 30 Prof. W. K. Hatt, of Purdue University, was made temporary chairman of the Commission, and L. H. Lewis, secretary of the Indianapolis Chamber of Commerce, was made secretary. A sub-committee, of which Prof. Hatt is chairman, is to form a plan of procedure to be reported to the next meeting of the Commission on May 12.

The Los Angeles Power-Bond Election on May 8 resulted in 56,077 votes in favor of the proposed issue of $6,500,000, and 23,161, against. A two-thirds favorable vote was required to pass the bonds and the proposition was therefore carried by a considerable margin. As explained in "Engineer News," Apr. 30, 1914, p. 986, this sum is needed to carry out plans now matured for the development of power at falls in the Los Angeles water-supply aqueduct and its distribution within the city. According to a statement of A. L. Stevens, City Attorney, the city will condemn the distributing system of the Southern California Edison Co.

Pittsburgh's City Engineering Work Consolidated—The Bureau of Construction of the Department of Public Works, Pittsburgh, Penn., has been broadened by consolidating with it the Bureau of Surveys. The enlarged bureau is called Bureau of Engineering. Besides doing all construction work, bridge maintenance, etc., it is also charged with doing the engineering work for sewer maintenance. This brings under one head all the engineering work of the city except conduct of the water supply and the executive part of sewer maintenance. N. S. Sprague, who has been in charge of the Bureau of Construction, remains in charge of the Bureau of Engineering.

An Immense Convention Hall with a seating capacity of 8000 has been planned by Egerton Swartwout, of the architectural firm of Tracy & Swartwout, of New York, for the proposed George Washington Memorial at Washington, D. C. Mr. Swartwout's design was awarded the first prize of $1500 in a competition to which thirteen architects were invited. The plans call for an auditorium 270 ft. long by 200 ft. in width, arranged as an ellipse, which, according to the designer is not only the most economical layout for disposition of seats, but also presents the best acoustical properties.

The building is a project of the George Washington Memorial Association, which has raised $500,000 of the $2,000,000 which will be required for its construction. The government has contributed a site on the Mall, at Washington, provided at least $1,000,000 can be raised by Mar. 4, 1915.

Organization and Plans of the Alaskan Engineering Commission—President Wilson's appointments of members of the commission to have charge of the location and construction of the government railways to be built in Alaska were announced in the personal columns of our issue of last week. The commission, composed of Messrs. Edes, Mears and Riggs is now on its way to Seward, Alaska, where it will establish summer headquarters, probably with a branch office in Seattle, Wash. The first work will be the survey of a route from Portage Bay to the vicinity of Fairbanks. It is unofficially stated that nothing definite has yet been decided upon in the way of filling the subordinate positions in the engineering staff. As men will be needed in a hurry it is probable that the appointments will be made without recourse to civil service examinations. The commission already has a number of applications on file. Applicants should address the Alaskan Engineering Commission, Department of the Interior, Washington, D. C.

A Unique Round the World Tour has been undertaken by two California engineers, Messrs. Sydney L. Ivers and Morris H. Poucher, of Torrance. The tour, which is planned to last two years or more, is undertaken partly for pleasure and partly to inspect engineering works in out-of-the-way corners of the world. The start is to be made from San Francisco on a sailing bark about the middle of May. At Honolulu a sailing boat will be chartered for exploration among the Hawaiian Islands. Thence the itinerary includes the Samoan, Fiji, Tonga, Cook and Navigator Islands in the South Pacific, and New Zealand, Tasmania, Australia, New Guinea and Borneo to the Philippines. From the Philippines

a northward jump is taken to Japan and then the trip proceeds through China, Malacca, Java, Sumatra, Siam, India, Ceylon, Arabia, Egypt and Turkey. In Europe, all the principal countries will be visited, and then passage will be taken across the Atlantic to Newfoundland and Canada; thence to Cuba, Panama, Costa Rica, Nicaragua and Honduras, finally terminating at Jamaica.

The Reorganization of the Massachusetts State Board of Health was proposed in a special message sent to the legislature on May 8. The bill accompanying the message provides for a single full-time paid health commissioner and for an advisory board. The Department will, if the bill becomes law, consist of a Health Commissioner at $7500 per year and an advisory council of six members at $10 a day for actual time. The State will be divided into eight districts with a paid health officer at the head of each, who shall devote his whole time to the work. The Department will have six divisions at the start: Administration, communicable diseases, sanitary engineering, food and drugs, laboratories and child welfare. At the head of each will be a director, who is to be an expert in his particular field of work. The department of vital statistics will remain with the office of the Secretary of State.

The Commissioner has the power of appointment and removal of the directors of divisions and of the district health officers, all with the approval of his council. He may when, in the opinion of the council, a health emergency exists, enforce the rules and regulations of the state department within the territorial jurisdiction of local health boards.

The Apartment-House Fire in Boston on Apr. 14, noted in "Engineering News" of Apr. 23, is the subject of a bulletin just issued by the National Fire Protection Association, 87 Milk St., Boston, Mass. Eight lives were lost. The Melvin apartment house was a five-story-and-basement brick building. An open elevator shaft extending from basement to roof and a dumbwaiter shaft provided flues which rapidly conducted the fire from floor to floor. The fire started in the basement, it is claimed, from spontaneous combustion in a locker. The janitor who discovered the fire at about 2 a.m. called from a window to a passerby to give the alarm. Apparently, the passerby considered the mere opening of the signal-box door sufficient. Several minutes later a policeman sent in an alarm, which was followed by a third and fourth.

Several conclusions are deduced. Such buildings should be equipped with automatic sprinklers. The basement at least, and all its lockers and partitions should be fireproof. The basement should be cut off from the floor above by standard fire-doors. A fire-wall should divide the building into two sections connected on each floor by fire-doors. Unbroken vertical openings from basement to roof should be prohibited. Exterior fire-escapes should be located, wherever possible, against blank brick walls. When it is necessary for fire-escapes to pass windows, the sash and trim should be of metal and the glass wired.

Projected Railways to Hudson Bay are becoming numerous. The Canadian Government is building a line in northeast Manitoba from the Canadian Northern Ry. to Port Nelson, and the provincial government of Manitoba in proposing a line north from Winnipeg to the same point. The provincial government of Ontario proposes to extend its Temiskaming & Northern Ontario Ry. to James Bay (the southern arm of Hudson Bay), with a terminal at the mouth of the Moose River, at the southwest corner of the bay, and the provincial government of Quebec has granted subsidies for the proposed North Ry. from Montreal to James Bay, with a terminal at the mouth of the Nottaway River, at the southeast corner of the bay. The Canadian Pacific Ry. is said to be contemplating an extension of its Kippewa branch north from Kippewa, Ont., to James Bay. The Temiskaming & Northern Ontario Ry. already extends from Toronto to Cochrane, Ont., on the Canadian Transcontinental Ry., and has had investigations made as to conditions for establishing rail and water terminals at Moose Harbor, the mouth of the Moose River (670 miles from Toronto). This is about latitude 52°, while Port Nelson is at about 57°, the outlet to the sea being still farther north. These investigations have been described in a paper by J. G. G. Kerry, consulting engineer for the railway, which was read before the Toronto chapter of the Canadian Society of Civil Engineers.

PERSONALS

Mr. Edward T. Stotesbury, of the banking firm of Drexel & Co., Philadelphia, Penn., has been elected President of the Reading Co., to succeed the late George F. Baer.

Mr. A. L. Robinson, former Superintendent of the Mechanical Division, Panama Canal, is now Consulting Engineer of the Barber Asphalt Paving Co., Philadelphia, Penn.

Mr. H. L. McLow, formerly Master Mechanic of the Missouri, Kansas & Texas Ry. shops at Greenville, Tex., has been appointed Manager of the Greenville municipal water-works.

Mr. Robert W. Hunt, M. Am. Soc. C. E., of Robert W. Hunt & Co., Engineers, Chicago, Ill., has been made a Vice-President of the International Association for Testing Materials.

Mr. Dalton R. Wells announces his withdrawal from the firm of Burrowes & Wells, Architects, Detroit, Mich., to enter private practice as an Engineer and Architect, 1601 Ford Building, Detroit.

Mr. E. L. Crugar, former Assistant Chief Engineer of the Chicago & Alton R.R., at Chicago, Ill., has been appointed Assistant Engineer of the Illinois Central R.R., with headquarters at Chicago.

Mr. W. J. Richards, M. Am. Inst. M. E., General Manager of the Philadelphia & Reading Coal & Iron Co., Pottsville, Penn., has been elected President of the company to succeed the late George F. Baer.

Mr. Benjamin B. Hatch, Electrical Engineer of the Boston, Mass., Schoolhouse Department, has been removed by **Mayor Curley, after 18 years' service in the department. His** salary was $2500 per annum.

Dr. Richard H. Harte, a prominent Philadelphia surgeon, has been appointed Director of Public Health and Charities of Philadelphia, succeeding Dr. Joseph S. Neff, resigned, as noted in our issue of last week.

Mr. A. C. Hinckley, formerly Master Mechanic of the Southern Pacific Ry., at Oakland, Calif., has been appointed Superintendent of Motive Power and Machinery of the Oregon Short Line R.R., at Salt Lake City, Utah.

Mr. R. F. Carr, formerly Superintendent of the St. Louis, Brownsville & Mexico Ry., at Kingsville, Tex., has been appointed Superintendent of the Southeastern division of the St. Louis & San Francisco R.R., at Birmingham, Ala.

Mr. I. C. Brower, Assoc. M. Am. Soc. C. E., former Division Engineer of the Chicago & Alton R.R., at Bloomington, Ill., has been appointed Assistant Engineer of Chicago, St. Paul, Minneapolis & Omaha Ry., with headquarters at St. Paul, Minn.

Mr. Emery Oliver, M. Am. Soc. C. E., Chief Engineer of the Natomas Consolidated of California, of Sacramento, Calif., has been promoted to be General Manager of the company, which has extensive levee building contracts on the Sacramento River.

Mr. A. K. Shurtleff, recently Office Engineer of the Chicago, Rock Island & Pacific Ry., has been appointed Engineer for the western group of the presidents' conference committee on valuation. Mr. Shurtleff's headquarters will be in the Burlington Bldg., Chicago, Ill.

Mr. J. W. Powell, formerly Assistant to the President of William Cramp & Sons' Ship & Engine Building Co., Philadelphia, Penn., has been elected President of the Fore River Shipbuilding Corporation, succeeding Mr. Francis T. Bowles, resigned, as noted in our issue of Apr. 23.

Mr. Frank T. Oakley, M. Am. Soc. C. E., recently Bridge Engineer of the Northwestern Pacific R.R., at San Francisco, Calif., has been appointed Senior Structural Engineer, Division of Valuation, Interstate Commerce Commission, Pacific district, with headquarters at San Francisco.

Mr. William B. Poland, M. Am. Soc. C. E., Vice-President and Chief Engineer of the Philippine Ry., at Manila, P. I., will leave the Islands on June 1, 1914, to return to the United States. It is not expected that Mr. Poland will return to the Philippines, as construction of the railways has been finished. His address is now J. G. White & Co., Inc., 43 Exchange Pl., New York City.

Mr. Albert A. Krieger, Jun. Am. Soc. C. E., Assistant Chief Engineer of the Louisville Water Co., Louisville, Ky., has been promoted to be Acting Chief Engineer to succeed Mr. Theodore A. Leisen, M. Am. Soc. C. E., resigned, as noted in our issue of Apr. 30. Mr Krieger is a civil engineering graduate of the Rose Polytechnic Institute and has been Mr. Leisen's principal assistant for a number of years.

Mr. J. Taffanel, former Inspector of Mines, France, and now Director of the French Mine Experiment Station at Lievin, is visiting this country as the guest of the United States Bureau of Mines. Mr. Taffanel is a pioneer investigator of

coal-mine explosions and he is in this country to collaborate with the United States Bureau of Mines in experiments being conducted at Bureau's experimental mine near Bruceton, Penn.

Mr. Peter E. Nostrand, M. Am. Soc. C. E., of Shelter Island Heights, N. Y., has been appointed County Superintendent of Highways of Suffolk County, N. Y. Mr. Nostrand was formerly Chief Engineer of the Ramapo Water Co., and in 1891-93 was Chief Engineer for J. D. & T. E. Crimmins, contractors for the construction of the Broadway and Third Ave. cable-railroads, New York City. Since 1895 he has been in private practice as Consulting Engineer.

Mr. Samuel C. Stickney, Assistant to the President of the Erie R.R. has been appointed Assistant General Manager, with headquarters at New York City. Mr. Stickney studied civil engineering at the Massachusetts Institute of Technology and began his experience as a rodman on railway location and construction in Minnesota in 1886. Later he was Locating Engineer, Superintendent of Construction and Engineer of Maintenance-of-way of the Chicago, St. Paul & Kansas City R.R. For two years following 1890 he was Chief Engineer of the Chicago Union Transfer Ry. In 1892 he went to the Chicago Great Western R.R. as Assistant to the President. Subsequently he was promoted to be General Manager and later Vice-President and General Manager. He joined the staff of the Erie R.R. in March, 1913.

Mr. Theodore Voorhees, M. Am. Soc. C. E., Vice-President of the Philadelphia & Reading Ry., has been elected President of the company, succeeding the late George F. Baer. Mr. Voorhees was born in New York City, June 4, 1847, and graduated from Rensslaer Polytechnic Institute in 1869. The same year he entered the engineering department of the Delaware, Lackawanna & Western R.R., where, after four years' service, he was made Superintendent of the Syracuse, Binghamton & New York R.R. For ten years he was with the operating department of the Delaware & Hudson Canal Co. In 1885 he joined the operating staff of the New York Central & Hudson River R.R. as Assistant General Superintendent. He was General Superintendent from 1890 to 1893, when he resigned to become Vice-President of the Philadelphia & Reading Ry.

Mr. Henry Goldmark, M. Am. Soc. C. E., has resigned as Designing Engineer, Isthmian Canal Commission, and has returned to this country, where he will engage in private practice, in partnership with his brother, in New York City. He entered the service of the Isthmian Canal Commission in 1906 and was stationed at its Washington office, in charge of designing, until 1908, when he was transferred to the Isthmus. He has had direct charge, under Col. Hodges, of the design of the lock gates, floating caissons, chain fender machines, and pontoon bridge, and has supervised the construction of the lock gates. The lock gates were completed in March of this year, several of the chain fender devices have been installed and found satisfactory, and the construction of the accepted types of caissons is in the hands of contractors in the United States. In addition, Mr. Goldmark has served in a consulting capacity in the designing of various operating machines, valves, etc.

OBITUARY

Charles L. Cummings, President of the Cummings Machine Co., New York City, died May 5.

Claude S. Haynes, Assoc. M. Am. Soc. C. E., Assistant Engineer, Bureau of Sewers, Borough of Brooklyn, New York City, died at his home in Brooklyn, May 5.

Mary Hayden Lord Swain, wife of Prof. Geo. F. Swain, of Harvard University, died at her home in Boston on Apr. 30, aged 47 years. Mrs. Swain was the daughter of William Safford Lord, of Salem. She was married to Prof. Swain in 1904. Two young daughters survive her.

ENGINEERING SOCIETIES

COMING MEETINGS

INTERNATIONAL RAILWAY FUEL ASSOCIATION.
May 18-21. 6th convention in Chicago, Ill. Secy., C. G. Hall, C. & E. I. R.R., 922 McCormick Bldg., Chicago, Ill.

SOUTHWESTERN ELECTRICAL AND GAS ASSOCIATION.
May 20-23. Annual meeting at Galveston, Tex. Secy., H. S. Cooper, 405 Slaughter Building, Dallas, Tex.

SIXTH NATIONAL CONFERENCE ON CITY PLANNING.
May 25-27. Toronto, Ont. Secy., Flavel Shurtleff, 13 Congress St., Boston, Mass.

MASTER BOILER MAKERS' ASSOCIATION.
May 25-28. Convention at Philadelphia, Penn. Secy., H. D Vought, 95 Liberty St., New York City.

NATIONAL DISTRICT HEATING ASSOCIATION.
May 26-29. Sixth convention at Rochester, N. Y. Secy., D. L. Gaskill, Greenville, Ohio.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
June 2-5. Annual convention at Baltimore, Md. Secy., Chas. W. Hunt, 220 W. 57th St., New York City.

MASTER CAR BUILDERS' ASSOCIATION.
June 10-12. Annual convention at Atlantic City, N. J. Secy., Jos. W. Taylor, 1112 Karpen Building, Chicago, Ill.

OHIO SOCIETY OF MECHANICAL, ELECTRICAL AND STEAM ENGINEERS.
June 11-13. Annual meeting at Toledo, Ohio. Secy., Frank E. Sanborn, Columbus, Ohio.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 15-17. Annual convention at Atlantic City, N. J. Secy., Jos. W. Taylor, 1112 Karpen Building, Chicago, Ill.

AMERICAN SUPPLY AND MACHINERY MANUFACTURERS' ASSOCIATION.
June 15-17. Annual convention at White Sulphur Springs, W. Va. Secy., F. D. Mitchell, Woolworth Building, New York City.

TRAIN DISPATCHERS' ASSOCIATION OF AMERICA.
June 16-19. Annual convention at Jacksonville, Fla. Secy., John F. Mackie, 7122 Stewart Ave., Chicago, Ill.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
June 16-19. Spring meeting at St. Paul and Minneapolis, Minn. Secy., Calvin W. Rice, 29 W. 39th St., New York City.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.
June 17-20. Sixth semi-annual meeting at Troy, N. Y. Secy., J. C. Olsen, Polytechnic Institute, Brooklyn, N. Y.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
June 23-26. Thirty-first annual convention at Detroit, Mich. Secy., F. L. Hutchinson, 29 W. 39th St., New York City.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.
June 23-26. Annual meeting at Princeton, N. J. Secy., Henry H. Norris, 29 W. 39th St., New York City.

AMERICAN SOCIETY FOR TESTING MATERIALS.
June 30-July 4. Seventeenth annual meeting at Atlantic City, N. J. Secy., Edgar Marburg, University of Pennsylvania, Philadelphia, Penn.

Montana Society of Engineers—At the 27th annual meeting held at Great Falls, Mont., Apr. 9-11, the following officers were elected: President, Reno H. Sales; Vice-Presidents, Martin H. Gerry and Arthur W. Richter; Secretary, Clinton H. Moore, Butte, Mont.

American Electric Railway Association—The annual convention will be held at Atlantic City, N. J., Oct. 12-16. The principal other cities considered by the convention committee were Boston, Mass., and Washington, D. C. The secretary is E. B. Burritt, 29 West 39th St., New York City.

Engineers' Club of Dayton—The Engineers' Club, of Dayton, Ohio, organized on Feb. 20 and incorporated in May, 1914, was formally opened on May 14. A reception to the ladies was held in the afternoon. The clubhouse, located on the corner of 2d and Madison Sts., is a large comfortable building, entirely remodeled and redecorated to fit the needs of such an organization.

American Institute of Chemical Engineers—Among the papers to be read at the sixth semi-annual meeting at Troy, N. Y., June 17-20, the following are included: "Septic Tanks," by Wm. P. Mason; "A Combination Water Softener and Storage Tank," L. M. Booth; "Ozone in Ventilation," J. C. Olsen; "Development of Rotary Furnaces," R. K. Meade. A number of inspection trips will be made to interesting points in the vicinity.

Western Society of Engineers—A special meeting was held at the Society's rooms in Chicago on Apr. 30, for an informal reception to the three engineers who have been appointed by the Chicago Real Estate Board as a commission to investigate and report upon the sanitary problems of the city, and upon systems of sewerage and sewage disposal to meet the present and future requirements of the city. The engineers are George A. Soper, of New York; James D. Watson, of Birmingham, (England); and Arthur J. Martin, of London, (England). After the social part of the meeting, the chair was taken by E. H. Lee, President of the Society, and a brief address explanatory of the appointment and work of the commission was given by John W. Alvord. The three visiting engineers then made addresses touching upon their views in regard to sanitary problems and referring to some of the conditions and sanitary works in London, Birmingham and New York.